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THE NAVAL AND MILITARY RESOURCES OF THE COLONIES.

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In giving effect to the wish of the Council by reading a paper on this subject, I desire, in the first place, to point out the difficulty which limits the possibility of its full discussion here. Resources—especially of War—must be practically available, capable of actual, if not of immediate, application or development. Now, in our great Colonies,[1] which offer the widest field for present inquiry, the possible development or the practical availability of such war resources as they possess rests with their own particular Legislatures.[2] Whether those elements of war-power shall or shall not be developed; whether they shall or shall not be made available; whether, in short, they are or are not in the true sense of the term "resources," are matters for their decision and not for this Institution to discuss. Therefore, the vital essence of the whole subject must here remain untouched.[3] Though it be not legitimate in this place to consider whether those things of which I am about to speak are or are not therefore really and truly our naval and military "resources," we, as Officers of constitutional forces, must not be blind to constitutional facts. Those who turn wistful eyes towards Greater Britain seeking for signs of naval and military help in that future no man can foretell, must not overlook the tangle of difficulties we Englishmen—home and Colonial—have made for ourselves in the present. The consolidation, development, or even the bare application of dormant or actual war force stored up in other Englands beyond sea are, from a naval and military point of view, purely theoretical questions based upon a complex variety of political assumptions. The carrying out of practical measures necessary for a common system of defence through the machinery of multitudinous

[1] Canada, Newfoundland, New South Wales, Victoria, Queensland, Tasmania, South Australia, New Zealand, and the Cape.

[2] *Vide* "Constitution of the Britannic Empire," Creasy; "European Colonies," Payne; "The English Constitution," Amos; "The Colonial Office List," Official.

[3] See speech of the late Premier of South Australia, vol. xxi, No. 91, p. 686, Journal.

Legislatures differently constituted is another and a wholly different matter. The one belongs to regions of naval and military science—obviously for these reasons more or less speculative, the other is a stupendous problem, statesmen—of England, Canada, Australasia, and the Cape, &c.—have to face.

In order to bring the subject placed in my hands to such a focus as shall render its brief consideration of the smallest practical value, it is, therefore, necessary to politically assume much. It must be taken for granted that the Colonial naval and military resources—whatever they may be—*are* the *common* heritage and present *common* possession of the whole British race. That they are available, can be developed, and may be applied by an homogeneously constituted State. Finally, that these resources are to be regarded practically as factors of one great whole, the value of each factor being relative to its use and adaptability in one common Imperial plan of action in war.

From any other stand-point it would be a simple waste of time to investigate the present sources of resisting power—as regards external defence—of any one Colony taken by itself, for none isolated and alone could withstand the organized attack of any first-class Power. Volumes might be, indeed have been, written respecting the direct defence of the Canadian boundary, but the supporting strength of England is vital to the whole question. Any one of the rich, prosperous, and great Colonies in the South Pacific might—under their present arrangements, and if single-handed—suffer severely from armed strength possessed even by such disorganized countries as Chili or Peru.[1] The Cape could not, unaided, stand against the fleet and army of Brazil.[2] Plainly, therefore, the naval and military resources of the Colonies can only be practically and usefully considered as

[1] Navy of Chili: 2 ironclads, "Almiraute Cochrane," and "Valparaiso."
10 small steamers.
Army of Chili: 1,200 cavalry and artillery.
2,000 infantry.
3,200
Navy of Peru: 6 ironclads, one being the notorious "Huascar."
6 steamers with armaments varying from 2 to 30 guns.
Army of Peru: 1,000 artillery.
1,200 cavalry.
5,600 infantry.
5,400 gendarmerie.
13,200

[2] Navy of Brazil: 18 ironclads, small
1 frigate
8 corvettes
23 gunboats
7 transports
57
Having an aggregate of 177 guns, 10,000 horse-power.

Army of Brazil: 3,280 artillery.
2,484 cavalry.
9,864 infantry.
427 Staff and special corps.
16,055

component parts of our great Imperial system. The object to be attained by that system being the security in war of the integrity of the dominions of the Queen, and the preservation of the manifold interests of the two hundred millions of human beings Her Majesty—by various Parliaments, Houses of Assembly, and Councils—rules.

I thus introduce the subject because, having been fortunate enough to have elicited discussions in the press of the various Colonies,[1] and having closely studied these and the opinions of eminent Colonial authorities, relative to Imperial Defence—I feel bound to express my conviction that no good and much harm may come of discussing this question concerning the Colonies without close regard to their constitutional status.

It is therefore due to this Institution to offer these preliminary remarks, and by doing so I hope to have made what is passing in my mind sufficiently clear without overstepping its laws.[2]

Introductory.

Colonies may be divided into three classes.[3]

1. Colonies Proper—Agricultural, Pastoral, and Mining; such as Canada, Australasia, and the Cape.
2. Plantation Colonies—such as the West Indies, Ceylon, and Mauritius.
3. Military or trading settlements—such for example as Cyprus and the Fijis, Bermuda and the Straits Settlements, Malta and the Falkland Isles, &c., &c.

Of these classes the first demands closest attention, for, as Heenan says, "the Colonists who form them become in process of time a "nation properly so called."[4]

Naval and military resources may be grouped under two heads, "raw and developed." Men, for example, are "raw materials," but the trained seamen and disciplined soldier are "developed resources." Coal and iron are "raw materials," the ironclad the perfect product of their development. It is therefore necessary to examine the nature of the raw materials before entering on questions of their present or possible future development.

Raw and developed war resources may each be divided into two branches of inquiry—men and material. The power of any people

[1] Those articles published prior to 1877 can be seen in a book entitled "Colonial "Defence and Colonial Opinion," which will be found in the Royal United Service Institution and Royal Colonial Institute Libraries.

[2] A perusal of the following will explain more fully what is necessarily left unsaid. The Journals of the "Royal Colonial Institute," 1870-79; Froude's "Short Studies on Great Subjects;" articles in the "Nineteenth Century," by Sir Julius Vogel, and Sir F. Hincks, and in "Fraser's Magazine," 1878, by Baden Powell, "*Imperial Federation*" *by F. Young*. See also the article in the last Christmas number of "Vanity Fair," by the Duke of Manchester, and the concluding chapter in Wilson's "Resources of Modern Nations," &c., &c.

[3] I borrow this classification from a most valuable paper on "The Colonial and "Indian Trade," by Dr. Forbes Watson, *vide* "Journal Royal Colonial Institute," vol. ix.

[4] Quoted in Creasy's "Constitution of the Britannic Empire."

to preserve by force their own possessions and their own freedom is a question of relative numbers and distinctive characteristics of races. The possession of material resources, however great, may in war prove a curse instead of a blessing to any people too numerically weak, or too numerously neglectful to prepare to turn them readily to organized account for purposes of self-preservation. Hence the second place—under each head—is here given to material resources. Considerations concerning naval and military resources of the Colonies, I therefore take in the foregoing order, and venture to remind you it is impossible to do more than hastily point to the most prominent features of so huge a subject.

Men.

Table I shows the distribution of population in Colonies Proper.[1] It will be seen that the aggregate population of the three great groups of Colonies is about eight millions, but the value of the war resources, apparently offered by these figures, must be qualified by reference to the various races swelling the total. The Aborigines of New Zealand are not included, nor have I taken account of the 100,000 Indians in Canada, nor of the 30,000 Chinese computed to have recently settled down at the gold-fields of Queensland. Without, therefore, taking these into account, it will be seen that from the total aggregate population I have named, some one and a half millions must be deducted. I produce this offset of one and a half millions from the total apparent numerical resources not as a precise statistical statement, but as a fair substantial protest against forming hasty conclusions as to Military Colonial resources from figures only. Besides non-Europeans so deducted, it must also be borne in mind that the German element in the Colonies is considerable, and that a German, until a naturalized British subject, can hardly be counted as a raw material of British war resources.

It is obviously impossible to enter further into details, but I would point out that, after making reasonable deductions, the aggregate resources offered by British population of the three great groups of Colonies Proper—*if estimated by numbers*—are more than three times those of Denmark, nearly double those of Portugal, and greater than those of Belgium. Canada in this respect bears fair comparison with the Netherlands, and Australasia with Switzerland. The ratio of increase of population of our Colonies cannot, however, be compared to any country of the Old World; Canada's population, for example, has increased some sevenfold in fifty years, and about doubled within the last five-and-twenty years. The aggregate population of Colonies in Australasia has more than doubled in the last sixteen years, and is now about seventeen times what it was when Her Majesty began to reign.

[1] The tables in appendices particularly concerning the Colonies must not be accepted as perfectly accurate; though some trouble to make them sufficiently correct has been taken. A careful examination of and comparison between the various sources of published information, home and Colonial, will show the difficulties of obtaining perfect accuracy at present.

It must not, however, be forgotten that numerical strength of population is—as an element of war resources—directly affected by reference to the territorial area over which distributed. Now there are some 389 persons to every square mile in England and Wales, while in Australasian Colonies, the most densely populated, Victoria, has but 10 to the square mile; and the least, Western Australia, but *one individual to every* 38 *square miles*.

In Canada, a population about equal to that of London is distributed over an area half as big again as that of Russia in Europe.

In viewing population as a raw material of war resources, it is to be observed that emigration from these islands to a foreign territory represents so much present loss of war-power to us, and an incalculable increasing gain of war-power in the future to a possible enemy.[1] The transfer of population from one part of the Empire to another merely varies the distribution of this element of strength, and such redistribution may—if utilized—be of inestimable military benefit in war. The pale-faced artizan, born, bred, and working in the fœtid atmosphere of an overcrowded manufacturing town at home, is a very inferior "raw "material" of war resources—to the hardy Englishman labouring by the shores of Winnipeg, the banks of the Murray or the Clutha, or on his "claim" in Griqualand West. The historian Froude has so eloquently and forcibly written on this subject that further general remark is needless. Some very striking passages from his "Short "Studies on Great Subjects" will be found quoted in Mr. Brassey's paper in the Journal of this Institution.[2] It is, however, proper here to call attention to the opinion of a military authority. "The "Canadians possess," says Lieutenant-General Sir Selby Smyth, "in "a marked degree, qualities to make excellent soldiers, being both "hardy and industrious, used to rough life, easily subjected to dis-"cipline, and willing to submit to necessary authority. . . . . There "are no better soldiers than Canada can produce."[3] Turning our eyes towards these islands, it must be acknowledged that manufacturing progress at home is rapidly absorbing rural populations, and shrinking the recruiting area which, from natural causes, provides the best raw material of military force. It is calculated our home population will amount in 76 years from this to some sixty millions, nearly double what it is now. We may therefore expect the quality of raw material yearly offered by home recruiting fields to diminish rather than to increase with numbers; while in our Colonies it is both in quantity

[1] During the 25 years ending 31st December, 1877, upwards of 4,000,000 persons (of British origin) emigrated from the United Kingdom, of which 2,700,000,—a number greater than the present total population of Switzerland, went to the United States. In 1877 the emigration was as follows:—

45,000 to United States.
30,000 to Australasia.
7,000 to Canada.
11,000 to all other places.

These figures are in round numbers for illustration of principles.

[2] See "A Colonial Naval Reserve," by T. Brassey, M.P., vol. xxii, No. 95, "Journal "of the Royal United Service Institution."

[3] See Official Report on "The State of Militia of Canada," 1877.

and quality increasing every year at a rate difficult to accurately estimate. It has, however, been calculated that, in some 21 years from this date, the aggregate population of Canada, Australasia, and the Cape will be some fifteen millions, nearly half what the total population of the United Kingdom is now—about equal to what it was at the date of Waterloo.

Before, therefore, the Naval Cadet of to-day is an Admiral; before the Sandhurst Cadet of to-day is a General Officer Commanding, Colonial population will form numerically a very substantial proportion of British war resources, and probably be superior in quality to that likely then to be furnished by the mother-country. The true value and availability, therefore, of this element of national war strength lies—as regards these Colonies—more in the immediate future than in the actual present; but, forasmuch as it takes at least a whole generation to build up a national, naval, or military organization, it is full time now to begin to lay the foundation of such a truly national system as shall embrace all the products of these British developments, and have for its object the welding together of the elements of English war strength into "one harmonious whole." It appears to me that a system which now does not do so, must, in a generation, be discarded as effete and obsolete, or remain—to produce gradual but certain disintegration of English war-power by excluding from its original sources of naval and military strength the more vigorous portions of our race.

Questions concerning the raw materials of war resources, offered by the subject races in Canada and at the Cape, should properly here be considered. It is, however, too special a subject to introduce incidentally. Such resources, whatever their true value, must ever be secondary to those furnished by British blood. Those at the Cape can only be fairly estimated when the present war is closed. In Canada the proportion of native races to British is very small, but it may be fitting here to quote from an Address to the Queen from the Chiefs of the Six Nations, "assembled at their council fire," during the Crimean War. "Great Mother," they wrote, "your children of "the Six Nations have always been faithful and active allies of your "Crown, and the ancestors of your Red children never failed to assist "in the battles of your illustrious ancestors."[1]

On the general questions relative to the Imperial availability of military resources furnished by native populations, I would venture to remark that the truth—as it generally does—would appear to lie between two extreme opinions. The one which describes a contingent of Her Majesty's Native troops commanded by distinguished British officers as a "horde of savages" is not worthy of scientific consideration, but the other extreme of opinion may become a source of real danger. It appears to be briefly this: that "Home defence" is one thing, and "Imperial defence" another; that so long as British pockets are full, a sufficiency of "billets for bullets" on distant battlefields can always be readily procured, and may be chiefly furnished by

[1] See papers presented to Parliament, 25th January, 1855.

the bodies of British subjects having a darker coloured skin. But if the teachings of history are to be trusted, this peace philosophy, based upon the sandy foundations of money and subject races will not, in time of trouble, avail us much. The signal at Trafalgar was surely not of momentary import, but for all time the Shibboleth of safety of England and her Colonies alike.

Table II shows approximately the distribution or population in Plantation Colonies. It will be seen that the war resources offered by white population are of little *numerical* practical value. Climatic and other influences combine to render it improbable that this element can ever be in *this particular respect* of much account.

Table III gives similar information concerning military and trading settlements, to which the same remark applies generally with greater force. These tables will be, however, referred to later.

Raw Resources, Material.

Out of innumerable materials necessary for Naval and Military purposes, it may here suffice to select three: Food, Coal, and Horses.

Food.

It must be remembered we are now considering Colonial Naval and Military resources as component parts of one great whole, of which the United Kingdom is the citadel. It is, therefore, of great naval and military importance to understand how that citadel is provisioned, and how far Colonial resources are capable of supplying its wants. According to the elaborate calculations of Mr. S. Bourne it appears "that out of thirty-three million inhabitants of the United "Kingdom, eighteen millions may be sustained on food grown at "home, and fifteen millions on that received from abroad."[1] He further points out "on an average, each member of the community "now consumes to the value of two and a half times as much foreign "food as he did twenty years back."

It is just ten years ago since in two lectures[2] here I endeavoured to show the extreme danger of limiting the military scope of National Defence simply to these islands. The aim of those papers was to draw attention to a disagreeable, and *then* most unpopular truth, viz., that military arrangements for *even a passive* defence could not be confined to the simple question of invasion, because without military aid abroad for our fleets to rest upon, the safety of our water roads was imperilled, and unless these communications were secured absolutely, we could be—starved out. The defence of our Imperial communications, be it remembered, is not a purely Naval question, but a very complex

[1] *Vide* paper read before the Manchester Statistical Society, "On the Increasing "Dependence of this Country on Foreign Supplies of Food." By Mr. S. Bourne, F.S.S., 1877.

[2] "Distribution of our War Forces," Journal, vol. xiii, No. 53.

problem involving a great variety of Naval and purely Military considerations.[1] The national necessity for no longer delaying to deal with it is increasing with marvellous rapidity. At the date, 1869, these papers here referred to were read, the value of the chief articles of food per head of population imported was at the rate of 37 *shillings and five pence* per annum, while by 1877, it had risen gradually to 57 *shillings and seven pence.*[2] The food required by fifteen thirty-thirds of our home population at present comes from various countries of the world; consequently we have a great variety of divergent supply lines. Our Imperial connecting lines must be defended irrespective of all other consideratious, and if our Colonies possessed food resources requisite to supply home wants, our food lines and our Imperial lines could, in war, become identical. So far, therefore, as the actual sustentation of our people at home is concerned, this would be equivalent to an increase of war strength; hence the close connection between Colonial food and Naval and Military resources.

Table IV illustrates the imports of food into the United Kingdom in 1877. It sufficiently exhibits the truth that we are not, as regards food, a self-supporting Empire. This is a great naval and military fact, and one on which the whole question of a real national policy of defence turns. It would be impossible here to push inquiry below the figures of that Table, but in order to explain its illustrative importance, brief further remarks may be useful.

Taking wheat, for example, we imported during 1877 fifty-four and a quarter million odd *hundredweights.* Of this, some forty-four and three quarter million *hundredweights* came from some fifteen different Foreign Countries,[3] but nine and a half million *hundred weights* came from our own possessions. Of this nine and a half millions, some six millions came from India, and three and a half millions from the Colonies. It is to be observed that of the total wheat required by these two Islands in 1877, only about one-ninth came from India—probably less through the Suez Canal—and only about one-seventeenth of the whole was furnished by the Colonies. We had, during that year, some eighteen different wheat supply lines, made up as follows: fifteen from Foreign Countries, one from India, one from Canada, and one from Australasia.[4] The great bulk, therefore, of the staple article of our food travelled in 1877 along lines by no means identical with the connecting lines of our Empire. The food-producing resources of the Colonies are consequently of great naval and military importance.

[1] If the Naval Prize Essay, 1878, Captain P. H. Colomb, R.N., Journal, vol. xxii, No. 94, be read in conjunction with "Strategic Harbours," General Collinson, R.E., Journal, vol. xviii, No. 77, and Pasley's "Military Policy and Institution of the "British Empire," 1808, the complexity and gravity of the question will be fully understood.

[2] *Vide* Report of the Chief of the Bureau of Statistics, for quarter ending June 30th, 1878. Official: Washington.

[3] About 21½ million cwts. came from the United States, and 10¾ million cwts. from Russia—two-thirds of it from Northern ports.

[4] About 6 million cwt. from India.
3 " " Canada.
½ " " Australasia.

What they are it is unnecessary, perhaps, to remind you. Travellers in Canada, Australasia, or the Cape see one common thing, they have but one tale to tell, unlimited food-producing resources belonging to the English race—lying waste. One of the inestimable naval and military benefits certain to arise from a natural redistribution of British populations—within the limits of their own Empire—is therefore briefly this, a diminution in the future of the number of food lines absolutely requiring protection in war. The value and availability, however, of Colonial food resources—inexhaustible though they be—lies, as a naval and military question, more in the future than in the present. They will increase relatively with the first element of war strength—population.[1]

Coal.

As a preface to remarks on Colonial coal, it is proper to say that they are necessarily cursory and confined to an infinitesimal portion of a great subject. Hence it is that no mention is made of some prodigious deposits, some recently discovered, others not yet much worked, in several Colonies. This paper is simply illustrative; closer and more adequate examination would directly concern Colonies not here mentioned, but nevertheless possessing such wealth.[2]

Coal is not merely a naval resource. Combinations and concentrations of our purely military forces are helplessly dependent on its supply. Before English soldiers could cross the Prah, for example, they had to cross the sea; and this preliminary movement of a small military expedition caused a variation in the export of British coal. The King of Coomassie was probably not aware that a light applied by even one unarmed man to a black mass at a distant Portuguese island would do more to delay the advance of his enemies than the muster at home of all his military hosts; nor did Zulu chieftains at Rorke's Drift know that the time of attack of a reinforced British Army might be more or less directly influenced by the coal-carrying capacity and coal consumption of ships selected as transports, or the quantity of fuel stored, and coaling arrangements at that same remote island of St. Vincent. Savages cannot be expected to know these things, but the English executive, Home and Colonial, will for once make a mistake if it expects the Moltkes or Todlebens of future wars to possess—in this matter—only the military intelligence of savages. The close connection between coal and our military movements is sufficiently indicated by the fact that in 1872 our export of coal to Madeira was less than 36,000 tons, to Cape Coast Castle 42 tons; while the year of the expedition, 1873, it was to Madeira over 46,000

[1] A great variety of interesting and instructive matter, particularly concerning Plantation Colonies and military and trading settlements is necessarily left untouched for want of space.

[2] A very excellent paper "On the natural Distribution of Coal throughout the "British Empire," was read before the Royal Colonial Institute by the *late* Mr. Eddy, 1872. Though the interval of time elapsed since it was read has altered the complexion of some of the facts, it is still, nevertheless, a valuable guide to a study of the subject.

tons, to Cape Coast Castle over 3,600 tons. If, then, the sending abroad during a time of profound naval peace of a small, compact military force—to punish a barbarous king—involved a variation of distribution of some 14,000 tons of British coal, how great will be the strain on our power of protecting and furnishing coal supplies and coal transport from England when at war with a first-class, and perhaps, attacking power! Colonial coal resources will then afford the only means of escape from an unworkable centralisation system on a huge scale. According as we have in peace utilised, developed, and prepared to guard them, so shall our Empire in war win the reward of intelligent forethought, or reap the bitter consequences of a stupid neglect.

Turn to the Dominion of Canada, with the Arctic Regions in its rear, and along the whole length of its front a power of infinite resources. The United States at the commencement of this century had a white population one-third less than the present aggregate of our Colonies Proper. Its present population now exceeds the aggregate of the United Kingdom and these Colonies together, and it is now the second maritime Power in the world. It is, for naval and military purposes, homogeneous, for its central Government can draw on and immediately apply every element of war-power found under its flag. Its left flank rests on the Pacific, and could be turned by sea from the province of British Columbia; its right flank, resting on the Atlantic, could be turned by sea from the province of Nova Scotia, and in its rear are the British West Indies. The combined naval and military operation of turning either flank, or attacking its rear, would primarily be a question of coal, and it is in these two provinces the Great Dominion finds its chief supply.[1] It would be impossible to enter into any examination here of the relative qualities of coal in the several Colonies or parts of Colonies. These points will no doubt be dealt with in the discussion which is to follow. I should, however, mention that space compels me merely to touch upon Colonial coal actually used now in any quantity by steamers on the sea. San Francisco steamers are largely supplied from British Columbia, while Nova Scotia furnishes some of our own steam lines, the "Allan" for example—with coal, besides exporting it to the States. I now ask you to cross, in imagination, by the Fijis from British Columbia to Australia; passing by Queensland—with its great coal deposits awaiting the hour of their full development—we arrive at Sydney. We are now in a Colony possessing a coal area of some 24,000 square miles in extent. At Newcastle, 75 miles up the coast, colliers will be found loading for various parts of the world. At San Francisco, Hong Kong, Singapore, and Galle, &c., their cargoes will be landed, and mingle with the coal of the mother-country, thus completing the black girdle with which British industry encircles the world. These laden vessels will, in war, be valuable prizes for hostile cruisers, and they will then require either armaments or escorts; still

[1] Large coal deposits have recently been discovered in the North West Territory, near the line proposed for the Pacific Railway which would connect Halifax with Esquimalt.

more will it be necessary to guard the sources of coal supply, and to arm and garrison those British points where coal is stored. Our Colonies, with their mother-country depending on the agency of coal for nearly all that makes them prosperous in peace, may fairly share with her—in just proportion—the honour and duty of its protection in war. Neither can hope successfully to secure its safety without painstaking preparation during peace. The mother-country cannot justly chide her children for heedless disregard, natural to youth, of a duty which she in her age neglects—as testified by unprotected British coal heaps scattered about the world. Time forbids special reference to other Australasian coal resources, such, for example, as those of Victoria, Tasmania, &c., or those of New Zealand, offering as they do, pledges of that "great maritime future," of which Sir Julius Vogel so eloquently speaks. Passing on our homeward way by the Mauritius to the Cape, we find a vast British territory, the mineral resources of which have not yet been so fully investigated as to warrant practical Naval and Military conclusions. We cannot, therefore, stop to inquire about the coal deposits in the Stromberg Mountains, Cape Colony; the Highveldt of the Transvaal, or at Biggarsberg, Natal. It is, however, at the present time, fitting to remark that our comrades advancing northward into the heart of Zululand are carrying the banner of St. George towards the Zambesi coal discovered by Livingstone. In our Plantation Colonies, there is no coal of present Naval and Military value.[1] Some, however, of these places like Military and Trading Settlements, are of immense Imperial importance as store supply depôts. Some particulars as to the rapid increase of British coal exports will be seen in Table V. To conclude this rude outline of Colonial coal resources, it may be observed that their Naval and Military value as regards Canada and Australasia lies in the present, and as regards the Cape, in a possible future. Canada and Australasia furnish the British race with the means of providing for its Naval and Military wants now—and in the future—in regions most remote from home supplies. How far we avail ourselves of them for Naval and Military purposes is altogether another question. To what extent we are preparing to make our war fleets—or the links in the distant chain of our Imperial communications on which those fleets *must* rest—depend on these natural sources of supply, are matters upon which I shall not now enter; but instead will conclude with two slight illustrations.

So far back as 1877, Mr. Donald Currie in his lecture[2] here, forewarned the country what might happen in a European war, through the absence of a submarine telegraph to the Cape. At this moment a savage, without even a big boat, has given the "greatest maritime "nation in the world" a small taste of the consequence of neglecting such practical views as were then put forth by Mr. Currie. Now it is from that lecture I extract the following pregnant sentence. "It was

[1] Labuan is an exception, but so many questions of detail would have to be raised concerning Labuan coal, that, in dealing with great principles, it seemed wiser to defer remarks.

[2] Journal, vol. xxi, No. 89.

" only a short time ago that the Admiralty inquired how much coal " we could spare at the Cape, and whether our fleet could be supplied " there, and it was impossible for the Government to learn in less " than fifty days their exact position." This, then, is one picture; in the foreground a Government in a seven weeks' ignorance as to the power of locomotion of the National Fleet; and in the far distance, that fleet—in waters of Imperial strategic importance,[1] trusting to a combination of luck and private surplus stores for its coal.

To look at the picture in another light, it is necessary to remember what Mr. Robinson, Member of the Natal Legislature, said in this theatre: "There exists in the part of South Africa to which I belong, " as fine a field of steam coal as exists in any part of the world. " That coal-field is 180 miles from the coast, and we are only too " anxious to get communication by railway, but, unfortunately, our " poverty and our smallness bar the way. If the Home Government " would co-operate with us to connect that coal-field with the sea, it " would open out to the British Empire a permanent and good supply " of steam-coal."[2]

In speaking from this place two years ago,[3] I drew particular notice to the defenceless state of our coal depôt at Hong Kong. Since that time circumstances drew special attention to that part of the world. England woke up thinking a war was close, and hasty preparations were made. Through the indefatigable exertions of two Officers,[4] defensive works were erected in an incredibly short space of time for the protection of this particular coal depôt. I am neither aware as to whether these works are sufficiently armed, nor whether the artillery force was sufficient to man them, but it is desirable to point out that Hong Kong is only one of a certain number of strategically placed Imperial coal depôts essential to our naval and military power of defence. In the same paper this sentence occurs: "If war breaks out to-morrow, it would " find our fleets without any system by which their supply of coal " would be assured." I venture to repeat those words again, and do so with the more confidence, because in this very theatre one year afterwards they were fortuitously, yet absolutely, corroborated by the distinguished Admiral who, at the time these words were spoken, was commanding the British fleet in the quarter of the world to which they referred. Last year, Admiral Ryder incidentally said: "I have just " returned from the command on the Japan and China station, and " with an imminent prospect of war, I felt very doubtful whether I " should ever get a pound of coal without taking it forcibly from a " neutral."[5]

Now my other illustration is this: During the year an Admiral "in

[1] The total commerce passing round the Cape, estimated by Lord Carnarvon at £160,000,000 per annum.

[2] *Vide* Journal, vol. xxi, No. 89, p. 241. Note. At Camdeboo, some 50 miles from Port Elizabeth, there is also coal of good quality.

[3] "Russian Development, and our Naval and Military Position in the North "Pacific," Journal, vol. xxi, No. 91.

[4] Colonel W. G. Stuart, R.E., and Assistant Commissary-General Moore.

[5] *Vide* Journal, vol. xxii, No. 97, p. 784. "Discussion on the Prize and other "Naval Essays of 1878."

"command" of a British fleet, in Chinese waters, "with an imminent "prospect of war," was doubtful as to getting a *pound* of coal,—the total export of coal from Canada and Australia exceeded a million tons, and at Newcastle, New South Wales, hydraulic appliances for rapidly shipping coal had been established at a cost of some £25,000 to the Colony.

Some further information respecting exports of British coal will be found in Table VI, and in conclusion I would commend to your special attention the following brief extract from a work called "Coal. "Its History and Uses." By Professor Green. Miall, Thorpe, Rüker, and Marshall. "This country's fortunes," they say, "are gradually "being merged in those of a greater Britain, which, largely through the "aid of the coal whose prospective loss we are lamenting, has grown "beyond the limits of these islands to overspread the vastest and richest "regions of the earth."[1]

Horses.

Turning from the agency on which war combinations over sea depend, means of transport for land operations naturally suggests itself for consideration.

It is fitting first to remind you that the prize of 5,000 roubles offered by the Czar, for the best "History of Cavalry from the earliest times," was gallantly won by Canada, in the person of Lieutenant-Colonel George T. Dennison, Commanding the Governor-General's Body Guard, author of "A Treatise on Modern Cavalry," and spoken of in Lieutenant-General Sir Selby Smyth's Official Report as one "among many "excellent Cavalry Officers of the Dominion.

The war resources of the Colonies in "Horses" is, I think, a question of immense importance. Armies in Europe are growing almost faster than horses fit for service are bred, and the number of horses required for war purposes increase in direct ratio to force to be placed in the field. A declaration of war is not exactly the time for a nation to be running about seeking horses for its guns, cavalry, and transport. It is all very well for us to rely on free-trade for our profits, and the supply of our national wants in peace; but when rumours of war are in the air, the Continental horse-market becomes, somehow or other, uncommonly "tight."

I remember, at one of our "Autumn Manœuvres," watching a regimental transport man struggling with a certain ugly pair of grey brutes, exhibiting a marked objection to a certain hill. There was no mistaking the nationality of the horses; nor was there much difficulty in determining that of the man, for between the vigorous strokes of

[1] The wealth of iron and other minerals of the Colonies is a great naval and military resource. Where iron and coal are found together in large quantities, as in New South Wales and the province of Nova Scotia or British Columbia and in other Colonies, the raw material resources of war are enormous. It was impossible, however, in a short paper to treat of these and many other interesting fields of inquiry. The inestimable benefit sure to arise from the attraction of population from the *one* old part of the Empire to many new branches of it, is the development of these material resources here left untouched.

his whip,—this,—free from adjectives,—was his refrain: "Ye don't "even speak English, ye brutes, ye don't!"

Now Table VII exhibits a fact—which naturally recurred to my memory then—that there are, in other Englands beyond sea, some two million horses[1] more or less accustomed to English ways, an English tongue, and an English hand. This may appear a theoretical mode of introducing a subject of great gravity, and may seem to infer obliviousness to great sea distances, and the effect on horses of long voyages: in short, to lack the possibility of practical application. I hope, however, that, on reflection, it may not so appear. It was impossible here to inquire into the merits and demerits of various Colonial coal; and, for the same reason, the characteristics of Colonial horses can form no portion of these remarks. It will, however, be of profit to this Institution—and, through it, to the Service—if the discussion elicits information on these points from gentlemen of practical Colonial experience.

The first general consideration as to horse resources of the Colonies is one of numbers; this, for purposes of illustration, is met by Table VII. It is to be borne in mind, however, that the same observation made respecting the extent of area covered by population applies, though perhaps in a more limited degree, to the "raw material" of war furnished by horses. An example of this truth was indirectly afforded by H.R.H. the Duke of Cambridge with reference to the despatch of horses to the Cape. In the House of Lords, H.R.H. said: "The "reason was obvious. To collect a large number of horses on the "spot would take time, and it was necessary that the men should go "ready to take the field on landing."[2]

The next general reflection is that as our Colonial Empire contains vast territory in every clime—from the frosty N.W. Province of Canada to the tropical districts in Northern Australia,—so are to be found within its limits, horses naturally suited to the purposes of war in any part of the world where British forces may have to operate. I may mention that in Queensland five shillings per head has been sometimes paid for shooting wild horses, in order to clear the "Runs" and to prevent interference with the domesticated animals.

Now as regards sea distances, which is the point on which the practical question of value and availability turns. No student of modern warfare can observe the increasing facilities of transporting live animals in large numbers over long sea distances—which have been created by the push and shove rivalry of peaceful commercial competition—without reflecting how means so afforded can be turned to account in war. To my mind, they furnish to us at once a warning and an encouragement. A warning, because they show that long sea distances do not *in themselves* present insurmountable obstacles to foreign attack: an encouragement, because we have only to *prepare* to avail ourselves of the experiences of peace and to consolidate the Imperial resources we possess—to render our Imperial position at all points practically secure. As a matter of fact the military obstacles

[1] The number of horses, returned by occupiers of land, in the United Kingdom, 1878, was 1,927,066. *Vide* Agricultural Returns, 1878.

[2] See Debate in the House of Lords, 21st February.

apparently presented by long sea distances—in the matter of horses—are theoretical obstacles imagined in peace, which, with good management and arrangement, vanish under pressure of war. In peace, large numbers of Australian horses, and no inconsiderable number of Cape horses, find their way to India and some time ago, British Columbia frequently imported horses from the Sandwich Isles, a distance of some 2,400 miles. The Mutiny in India compelled our establishment there to draw largely on Australia for horses, and the bustle of their embarkation at great ports like Melbourne and Sydney told the tale of Military requirements of war capable of fulfilment from points 5,000 miles distant. Recent events in one corner of the world caused a native cavalry force to be moved from India to Malta. Across 4,000 miles of sea it came, showing Englishmen — Home and Colonial—that steam has bridged not only the Channel, but the water distances which separate the various portions of our Empire from the mother-country and from each other; and reminding all, that Empire is not merely something "to be enjoyed" in peace, but that it has to be "maintained" by force in war. Again, cavalry, which, six weeks ago was at Hounslow and at Aldershot, is now across the Tugela, 6,000 miles away, thus completing a practical illustration of possible reciprocity of duty and obligation between England and her Colonies. If we can go to them, they can come to us.[1]

It must be remembered, however, that we are now regarding horses as "raw material" of war-power; the "charger" or "battery "horse" is a developed material. The certain change from one to the other is but a matter of time and skill, accomplished by forethought and resulting from care, and therefore these short notes under this head may, I think, be thus summed up. The value of military resources of the Colonies, as regards horses, lies in the present, and their availability depends upon the nature and extent of arrangements made in peace, by which alone they can, in war, be turned to organized and instant account.

While we remember that cavalry has been rapidly moved from England to the Cape, and swiftly from Bombay to Malta, let us not forget that there are in Canada, for example, nearly a million horses and "many excellent cavalry Officers;" that Ottawa is *nearer* Constantinople than London is to Pietermaritzburg, and that Bombay is *farther* from Malta than Malta is from Halifax.

It is now time to close this rude survey of those "raw materials"

[1] In advocating the appointment of a Royal Commission to inquire into the question of Imperial defence, the writer of this paper, speaking in 1873 (of the reciprocity of duties and obligations between England and the Colonies, and of the common duty of strengthening and protecting the points which command the Imperial road), made use of the following words to convey a meaning more practically exemplified by the presence of Indian troops at Malta five years later: "With the "creation of Imperial fortresses commanding the Imperial roads would grow up a "feeling of common security. They would be links in the chain which binds "together the military forces of our Empire; *stepping stones by which those forces "can cross to afford mutual assistance and support.*" *Vide* "Colonial Defence," Journal Royal Colonial Institute, 1873.

of Colonial naval and military power which appeared to me most worthy of selection for these short remarks. Whether you agree with me in the general conclusions I have thus far attempted to indicate, or whether you do not, you will not, I hope, at all events, be disposed to differ with the following general conclusions. That from a naval and military point of view, the application to any Imperial purpose of such outlying sources of war-power as the Colonies possess rests practically on means of transport and the ensured safety of the sea. The Colonial Mercantile Marine may fairly claim its place, therefore, under the head of "developed resources," and, with the armed strength, and naval and military organization of the several Colonies, will form the subjects for consideration in Part II of this paper.

Brief, and entirely inadequate though these references to the raw material of Colonial war-power may be, they form a necessary introduction to the consideration of such developed naval and military resources as the Colonies possess. They will, I trust, not be without some slight value. Their very insufficiency will, at all events, show that beneath the surface, over which we have so lightly passed, are yet unfathomed depths of useful study. Great as the natural advantages of England have been in the past, great though they still be in the present, they seem but shrivelled and stunted when compared with those of Greater Britain. Whether the power of self-preservation derivable from such aids will, in days to come, split into fragments, or become united and consolidated, must more or less depend upon the direction of present progress. Either result will more probably be developed from gradual growth, rather than spring from spontaneous or sudden change. If Colonial resources, as they become available, are not grafted into one great defensive system for a common purpose and a common good, then our Imperial power of resistance already contains elements of naval and military disintegration, and lacks that unity which is strength.

I cannot, therefore, conclude this portion of my subject without reference to one or two facts which afford some indications of the direction of present progress, and I shall take the heads of this paper in inverse order.

As regards Horses. In 1873, a Committee of the House of Lords inquired into the question of Horse Supplies. It was stated to the Committee, that "in case of emergency arising, the Continent would "be virtually closed to us for the purchase of horses." In reply to the 1643 question, Canada was referred to as "another country where we "could get horses," but which had not been mentioned. Out of 4075 questions only 33 had reference to Canada; but one witness—Colonel Jenyns—was examined as to Canadian horses. He stated that "they "were wonderfully good horses . . . as good troopers as he ever "saw," and that "they stand a great amount of hard work and "exposure." He was asked would he bring them over in *sailing or steam vessels*. There is no mention of Canada or of any Colony in the Report. So far as I am aware, we are not in any way preparing to make ready use of the available horse resources of the Colonies on an emergency, though we know full well we shall want horses, and that

we shall not get them from the Continent. The direction of present progress, therefore, does not appear to me to be encouraging.

As regards Coal. In papers presented to Parliament on Naval trials of Coal, 1877, I find it reported "that the classes of ships comprising "the larger proportion of the vessels on the China Station should not "in future be replaced by similar vessels; *or that coal giving different* "*results should be supplied to the depôts on the station.*" Now the British coal most readily obtainable on that station and on the South Pacific and Indian Ocean, is Australian. Can anyone say which is the principle of our Naval policy—whether coal is to be adapted to the ships for service on these stations, or the ships to the coal? Is Mahomet to go to the mountain, or the mountain to Mahomet? Until that question is fairly and practically answered, it is hard to say—as regards coal—in which direction Naval progress lies. If, without regard to the nature of British coal found on certain stations, we despatch vessels and fleets with arrangements not adapted to produce maximum results with any other than Home coal, we are not making proper use of our available Naval Colonial resources, and are endeavouring to carry on the defence of an Empire with resources found only in one small corner of it. The question of boiler and furnace arrangements determines a far wider one, viz., whether we are to drag coal across the world to our fleets or to draw on British resources close at hand. But that is not all. Are we to suppose that because Australian coal does not give equally good results as Welsh coal—in our present ships, that the question ends there? Is Australia to have no Naval future because her coal does not exactly suit the war vessels the mother-country chooses to construct to-day? Act as we may, Australia will grow, flourish and develop, and if we do not now begin to realize the advantage of *dovetailing* our Naval system into her available resources, when are we to begin? Turn to Table V, which shows that since the Crimean War, the export of coal from one Colony has risen from 60,000 tons in a year to nearly *one million.* Our children now may live to see the annual export of coal from Australia exceed that from the mother-country. Whose business will it be then to protect that supply in war? Will it be England's or Australia's, or our Empire's? The answer to such a grave question can only be dimly discerned through the mists of present Naval progress.

It is to be noted that (as will be seen by Table VI), not quite three million tons of British coal were exported in 1877 to British Ports abroad, while over thirteen million tons went to Foreign Ports. We have every advantage as regards geographical positions for storing coal afforded by our Plantation Colonies in the West Indies. It is an important fact that out of some 475,000 tons of British coal exported to that quarter of the world in 1877, but 172,000 tons went to the British, while the rest went to the Foreign West Indies. Had war broken out in that year, our enemies would, in that district of the world, have had greater facilities of coal supply than our vessels. In the matter of coal, and as regards these Colonies, our progress tends to throw the balance of naval power from them towards ports that in war will be neutral.

As regards food. Most Officers must, I think, have found that naval, military, and marine pensioners are every day finding it more and more difficult to provide at home for themselves and their families. Their families have, as a rule, been brought up in an atmosphere of order, cleanliness, and discipline, and benefited largely by education at the expense of the State. Take these facts into consideration, together with the waste of food-producing resources, and the manifest desirability of fostering cordial feelings in the Colonies towards the British seaman and soldier, and reflect that while we are at our wits' end to provide inducements to serve in the Army and Navy, the word Colonies, as suggesting a means to an end, is never even whispered. Russia, as an inducement to her seamen to settle at Vladivostok, moves their wives and families free of expense from one side of the world to the other, and can we with our magnificent territories do for our seamen's and soldiers' families—nothing? It is important to remember that even now in the great English continent of Australia wondering English children listen to their mothers' description of British soldiers once seen by her there, and that is all the next Australian generation will really know about them.

In conclusion, and as directly bearing on the food question in its wider aspects, I commend to earnest attention the following short extract from the proceedings of "The Lords' Committee" on Horses. Referring to the incidental allusion to Canada by Sir H. Storks—a sort of official right-hand of the War Minister of England—the following question was put to him, and the following answer given. *Question:* "In the event of a war with France or any other great "Naval Power our importation of horses would naturally be interfered "with, and that would be a great difficulty, would it not? *Answer: Yes, "certainly.*" Now if the importation from Canada of a few thousand horses, will when at war with a great Naval Power "*naturally be interfered with,*" what is to become of the fifteen thirty-thirds of our home population dependent on eighteen different lines for their food?

Friday, April 4, 1879.

Admiral Sir COOPER KEY, K.C.B., F.R.S., Member of Council, in the Chair.

Part II.

Developed Resources.

Shipping.—Having, in Part I, briefly touched upon some of the "raw material" of war possessed by the Colonies, we have now to glance at their "developed resources." Shipping demands first consideration, for no matter what may or might be the war-power of outlying portions of the Empire, it can only be applied through and by the aid of ships. Table VIII gives the number and aggregate tonnage of the vessels belonging to the whole Empire, at the same time distinguishing the total mercantile marine possessed by each class of Colonies.

It is to be observed that Canada alone stands *fourth* on the list of the mercantile navies of the world; the United Kingdom being *first*, United States *second*, and Sweden and Norway *third*.

The aggregate tonnage of the mercantile marine of Australasia is about equal to half that of Russia, while the mercantile marine of our Plantation Colonies is more than double that of Portugal. The total aggregate tonnage belonging to our Colonial Empire is by more than half greater than that of France, by about half greater than that of Germany, and not very far short of being double that under the Italian flag.

These are interesting and striking facts, and superficially regarded, they are apt to be construed as indications of immense and immediately available maritime power. Let us briefly examine whether this be a correct conclusion.

It will be observed that the military and trading settlements, taken together, have only an aggregate of 845 vessels, and as these places are scattered and far apart, and the average tonnage per vessel is only about 125, the war value of this portion of the Colonial mercantile marine is practically nothing—except as affording the Empire a series of small training schools, in which, free of public expense, men of various races receive nautical knowledge. That knowledge does not of itself, in these days, make a war seaman, *and in the absence of any arrangement by which our navy can strengthen itself in distant parts of the world*, readily and at once, it is, I think, quite possible that, generally speaking, the Colonial mercantile marine may—under present circumstances—be found to offer more temptations to our enemies than resources of strength to ourselves.

The Plantation Colonies only possess one steamer over 800 tons,

this belongs to Hong Kong. It appears to me therefore that any resource offered by the mercantile marine of Plantation Colonies must have reference to men, not ships, and in the absence of any effort on our part to husband and organize such resources, the growth of the Plantation mercantile marine increases proportionally the burden on the Royal Navy without adding to its power.

Turning to the Colonies Proper, Canada owns 9 steamers over 800 tons:—

3	over 800	and under	1,000	tons.
4	„ 1,200	„	1,500	„
1	„ 1,500	„	2,000	„
1	„ 2,000	„	3,000	„
9				

Australasia has but 3 steamers over 800 but under 1,000 tons; it is therefore useless to preach naval "self-reliance and self-defence" to those Colonies.

I trust I have said enough to show how necessary it is to look below the surface of figures in the matter of estimating Colonial resources of war. I grant that the mercantile marine of a country represents proportionately maritime power, but it is too often forgotten that it is *power in a latent and dormant* state. Its real, actual, available value as a war resource, entirely and altogether depends upon the readiness with which it can be converted from latent power into visible force. Without Imperial arrangements by which such change in the Colonial mercantile marine can be readily made, I verily believe there is serious ground for thinking that in the outbreak of war, it may prove a source of naval weakness rather than a source of naval strength. Take Canada for instance, with a mercantile marine greater than that possessed by any European Power, except Sweden and Norway; what a picture is here presented of immense dormant naval power, combined with actual naval helplessness! Our Imperial arrangements are such that though home ports are always more or less filled with effective reserve ships, none are ever laid up in Colonial ports. If war broke out, many of these ships kept at home would be commissioned and despatched to those water districts of which Canada and Australia are the natural bases; but we prefer to bring these ships backwards and forwards across the world at great expense, rather than leave them in reserve in Colonial ports, where they could be maintained at perhaps a less cost, and where they would, at all events, be invaluable in peace as naval depôt-centre training ships and schools of instruction for an Imperial naval reserve; while in war they would be more ready to hand for distant service than if laid up in home ports.

If the latent maritime power of the enormous mercantile marine of the Colonies is incapable of ready conversion into visible force, and furnishes no practical resource whatever for what we term the Imperial Fleet, it is simply because we do not choose to provide the machinery, nor to make the reciprocal arrangements necessary to turn it to account. Meantime, the Colonies are growing, "while we are "sleeping," and every year of such growth adds to the defensive duties

and responsibilities of the Royal Navy, without adding to its ability to meet the increased demand. It will be advantageous to defer further remark on this particular portion of the subject, until some general considerations respecting the organization and armed strength of the Colonies have been roughly indicated, and to these we will now pass.

Remarks on Armed Strength.

Before attempting to outline the salient features of Colonial Naval and Military Organization, &c., it is necessary to define broadly what are the lines of inquiry I propose to adopt. Briefly, then, I may say it appears to me more useful to examine them with a view to forming general conclusions of Imperial importance, rather than attempt to inquire into the merits or demerits of purely local systems, which would be not of general interest, and impossible to do fairly in a short space.

These organizations can only properly be understood by reference to their common origin; the soils, so to speak, in which they have been propagated, and in which some apparently flourish, some languish, and some have withered and died. To trace their common origin to its true source would necessitate examination of questions neither naval nor military, and must not here be attempted; but in order to approach the subject in an intelligible manner, it is necessary to bear in mind the changes in military distribution and organization which have taken place, and also the development of our Colonies during a period of remarkable progress and prosperity. To those, therefore, it is necessary in the first place briefly to refer. I leave out entirely Mediterranean stations and garrisons, and, of course, India.

When Her Majesty began to reign, the Colonial Empire consisted of 24 Colonies and Settlements, having in the aggregate less than 4 millions of population, a total revenue of less than $2\frac{1}{2}$ millions sterling, and the total aggregate annual value of their exports and imports was some 30 millions sterling only. At that time we maintained in those Colonies a military force of about 27,000, some 10,000 of which were stationed in the West Indies; some 5,000 in British North America, then consisting of seven separate Colonies; the remainder being quartered at the Cape, in Australasia, Ceylon, Mauritius, and a few other places; the cost of such forces being given in a Parliamentary paper at some $1\frac{1}{2}$ million sterling. The Crimean War found the foregoing distribution but little changed in principle, though some variations in detail had taken place. For example, the West Indian garrison had fallen from 10,000 to about 5,000, while the Australian had risen to a total of 4,000. A Parliamentary paper published in 1859 shows the average Imperial Force maintained in these Colonies in each year, from 1853 to 1857 inclusive, to have been nearly 27,000. I again remind you I exclude Mediterranean stations. This force included 6 resident corps,[1] borne on the strength of the Royal Army, and provided for in the Army Estimates, all of which have since been

[1] Newfoundland Companies, Ceylon Rifle Regiment, Cape Mounted Rifles, St. Helena Regiment, Gold Coast Artillery Corps, and Falkland Island Company.

abolished. In 1858, just 20 years after the date here taken as the starting-point of comparison, there still was no change in *principle* of distribution, nor not much variation in the cost of maintenance, but the following remarkable changes had taken place meantime in the position of the Colonies; the aggregate population had more than doubled, the revenue had more than quadrupled, the annual value of their exports and imports had trebled,[1] and the number of Colonies had increased by eight.

The principle of military distribution, however, though it had stood a test of many years and two great national struggles, one in the Crimea, and one in India, was open to one great military objection, viz., that the disposable force being limited and inelastic, the permanent quartering abroad of so large a proportion, left the garrison of the Grand Base, the United Kingdom, dangerously weak. The militia had been neglected, no reserve had been provided, and in spite of the repeated warnings of the most eminent military authorities, no system whatever had been provided for the defence of these Islands, nor for strengthening and supporting the Army quartered at home, except by calling in the outlying portion.

There was one other objection, which on purely military grounds had good foundation. All the Colonial positions occupied by Imperial troops had not been chosen for Imperial Naval or Military reasons, nor were the numbers regulated so much with regard to military necessities as by trade interests and political causes. The very best strategic positions we had taken by force, and knew their worth, having learned it by the bitter experiences of great naval wars. Since those wars, great developments had taken place, the foundations of branch British Nations had been laid, and a new world of civilization and progress opened in the Pacific. The simple fact that we have not yet had to fight for strategic positions in the South Pacific, may in some way account for the circumstance that we never did and do not now maintain any Imperial naval establishment there. The original causes of our having troops in Australasia were not military, but purely civil, and we find them there in 1858, long years after the civil necessities for the presence of military force had ceased.

This, then, was the state of things twenty years ago, and it is quite plain that the theory of English defence then, as handed down to us by naval experience, was based on the assumption of necessity for being prepared for an attack at any part of our position and that the arrangements for the defence of an Empire could not be confined to but one portion of it only. In practice it was defective, because, as before remarked, many of the positions were not well chosen; and political and trading interests had overruled military caution and thus left the United Kingdom so weak as to be well-nigh defenceless. Up to the time to which I refer, the military forces of the Empire consisted of regular troops and militia. The constitutional machinery by which the State could organize and train English manhood into an armed militia for purposes of defence existed. It was rusty and re-

[1] 1858. Aggregate of Colonial population, 8,148,641; revenue, £10,259,292; value of exports and imports of the Colonies, £93,630,750.

quired oiling and repairing, but nevertheless the power existed and was ready to hand at home and in the Colonies. Military authorities had for years been endeavouring to have it examined, repaired, and improved, but successive Governments paid no heed to their warnings, for the nation looked upon such matters with coldness and apathy. Then suddenly came the invasion panic, arising from unexpected declaration of war by France against Austria and the rapidity of its consequence. This panic was really due to an acknowledgment of the powerlessness of resisting direct attack upon the Imperial base which military opinion had been for years persistently, but vainly, pointing out to a nation that would not see. Before any one had time to think, an enormous section of the English people of Great Britain had rushed to arms and was busy organizing and drilling itself into a volunteer army. Government *followed* whither the movement led. The militia were for a time forgotten and the theory of Voluntary local or home defence was established as a cardinal principle of our military system, and rapidly took such deep root in the English mind at home as to gradually produce a complete revolution of our Colonial military arrangements. It soon became apparent that the Invasion question was not so simple as uneducated popular military enthusiasm imagined. Attention consequently turned to the militia and to the Army. This at once involved serious financial considerations, and thus military expenditure in the Colonies became a part of the question of the defence of the English coast-line, while the defence of the Colonies ceased to be a national military question and came to be regarded as something not of Imperial concern but of local and individual interest to each Colony only. Having sprung from a common origin it is not therefore surprising to find that all Colonial defensive systems have leading characteristics in common, distinctly traceable to the mode and circumstances under which the creation of such systems became, more or less suddenly, necessary. It is, however, right to say that the particular history and circumstances of each Colony largely influenced the nature and degree of the individual efforts made. For example, Canada at once started with a militia system of a business-like character to which I shall presently refer, while other Colonies mainly relied upon the voluntary efforts of patriotic individuals to whom permission was given to organize defences subject to certain conditions. On the one hand, Government assumed the responsibility of compelling citizens to defend their country: on the other, Government, in many instances, avoided the responsibility by leaving it to the citizens to do so or not as they liked. But however different at starting may have been the mode of proceeding by which military safety was intended to be attained, there was one fundamental principle lying at the root of all. It was this—that the defence of each Colony concerns itself only and should therefore be of a purely local character: in a word, that the "open sesame" of Colonial safety lies in the two words—Home Defence. That term is now popular throughout our Empire, but the general adoption of the military principle involved is, I think, worthy of serious critical examination. I have often asked, What are the territorial limits as defined by the word "Home" in conjunction with the word

"Defence"? I have never seen a reply. But it may be useful to point out that in Great Britain the obligation of Home Defence is deemed to end—for the greater portion of our military forces—at the water's edge: while in Australian Colonies it has been assumed to terminate at a land line marked on the map as separating two English Colonies: and I could name a Colony elsewhere which by a carefully and elaborately-drawn law declared it to end at the precise distance of 4 miles from the capital! no officer or man was to be compelled even to march beyond that magic line, and could not even be called out within it until the enemy practically was in sight. So far was this principle of local obligation carried at the Cape, that up to last year the military organization for the defence of the Colony was by territorial divisions, the inhabitants being "organized for the internal defence," *not* of the Colony, but merely of "their respective divisions." When trouble came, its chief sting lay in the fact that military combinations had been legally paralyzed by Act of Parliament. In New Zealand, at this moment, "no militia officer or militiaman in any regiment can be "carried or ordered to go beyond the boundaries of the districts for "which such regiment or independent company is raised, except only "such as shall volunteer for service out of the same."[1]

No one will dispute there are greater facilities for safe and rapid intercommunication between all parts of the British Empire now, than there were between all parts of England in the 13th century. It is an interesting fact that in 1285 the English freeman armed for defence was not protected by law from leaving his county or shire "upon the coming of strange enemies into the realm." The truth is the British Empire in its military constitution now is not so far advanced as England 600 years ago.[2]

Now it may be said we have regular troops enough to move to every part of the Empire when wanted, and therefore it is not in a naval and military sense objectionable for each part of the Empire to tie up its forces with parliamentary strings. But when the Empire is acting on its defence, its small regular army, being its only English arm of attack, must not be absorbed by even Imperial positions of passive defence abroad; and if all the rest of the military forces are immovable, our Imperial position cannot be made strong at the points where it should be strongest. When we recollect that in order to send a handful of troops to Zululand we have had almost to break up several regiments, we should not be too sure that our only movable force is prepared to stand an Imperial strain. But it may be said these local military forces, home and Colonial, are merely supplementary. If so, let it be clearly understood to what they are supplementary. At home no doubt they are supplementary to the regular army, their duties and positions being clearly defined; but what do Colonial forces supplement? Not a general plan of Imperial defence, for no such plan or scheme exists. The principle on which we rely for ensuring a maximum amount of Imperial safety, with a minimum of force and expenditure, is in itself vague. It is shortly expressed in the concluding paragraph of the report of the

[1] *Vide* "New Zealand Militia Act, 1870." [2] "Military Forces of the Crown," Clode.

Select Committee of the House of Commons in 1861. "Your Com-"mittee submit that the tendency of modern warfare is to strike blows "at the heart of a hostile Power; and that it is therefore desirable to "concentrate the troops required for the defence of the United King-"dom as much as possible, and to trust mainly to naval supremacy for "securing against foreign aggression the distant dependencies of the "Empire." From this it would appear that Colonial military forces are supplementary to Naval supremacy, or rather that it is reasonable to regard them as supplementary to our fleets. Now the power of a fleet is in proportion to its absolute freedom from duties of territorial defence. The two leading principles of Naval distribution may be said to be—1st, Off the enemy's coast; 2nd, Covering the commanding points of communications on the high sea. To secure our Naval bases and to furnish sufficient means for their local defence is an Imperial duty which I humbly submit we ought not longer to shirk, and in its discharge should seek to enlist the hearty co-operation of our brother Englishmen in the Colonies. It is to be observed that if military forces, created as supplementary to Naval power, are constituted on the principle of *immobility*, the operations of the fleet become dependent on the regulations of military forces rather than on the necessities of the naval work to be done. The naval bases must be then selected, not because they are most suitably situated, but because military forces have established themselves regardless of naval necessities. There is no alternative between that and a sacrifice of Naval power by using sea-going force to protect fixed points. But there is one more danger arising from the adoption of the principle of immobility of military force to which I desire to draw attention. If fragmentary local protection be a sound military principle of Imperial defence, but a short step leads to localizing Naval defence, either by Acts of Parliament, or still more surely, by war vessels incapable of keeping the sea. Already there are distinct proofs of Naval Colonial defence—to say nothing of Home—theories developing local proclivities. I observe so eminent an authority as Sir W. Jervois recommending, for example, South Australia to expend some £150,000 of her capital and £13,000 a-year of her revenue on a three-masted ironclad for purposes of local defence. She is not to be a regular sea-going ship, but is to be fit to go a certain distance, equivalent to that between Lisbon and the Azores. Sir W. Jervois thus officially speaks of the duties of the Royal Navy in Australian waters: "The Imperial squadron, small, and composed of "wooden vessels, being charged with visiting the islands of the South "Sea, with the defence of Fiji Islands, New Zealand, and all "Australian Colonies; the chance is but small of its being available "for the special defence of any one Colony or any particular portion "of the coast."[1] We have here a clear illustration of the Imperial programme for maintaining economically our Naval supremacy. We annex Fiji, being a position of great strategic importance, a necessary point at which to store coal and naval supplies, and as soon as we have got it, it simply becomes a burden to our fleet, because we do not choose to prepare to locally protect it, and because the military

[3] *Vide* "Sessional Papers, South Australia," 1877.

forces supplementary to our fleets are immovable, and none can be detached to so important a position. We took the point as a means of strengthening our naval position, and our arrrangments are such that we must weaken our naval position to defend the point. I have thus dwelt at some length on the one principle, common to all our Colonial defence systems, because it appears to me to deserve very serious consideration. I venture to think it may lead us by a perilous path to an Imperial slough of naval and military weakness.

As regards the influence of local circumstances on the nature and growth of Colonial systems springing from a common original cause, I submit but one brief general observation. It would be unreasonable to expect all Colonies to have acted alike when no sealed pattern, as it were, was left as a guide, and no steps taken to assist in securing uniformity. Canada had, and has still, exceptional advantages, not only enabling her, but prompting her, to strike out a military policy more or less distinct. She has, what other great Colonies have not, a great and glorious military history of her own. Before she was called upon to organize her military system, she had organized a considerable militia force; and further, large bodies of the regular army, of all branches, had for generations been quartered in her cities and towns. Besides all this, she is an old-settled country, and having passed the feverish time of petty provincial jealousies, seeks, as a united Dominion, a system worthy of consolidated power and enlarged responsibility. It is but right to make this observation, for much misapprehension prevails at home as to the varied circumstances and conditions of other Colonies as regards military capability and power, and some Colonies are often ignorantly blamed for what they cannot help.

I will now briefly indicate outlines of military organization in the Colonies.

ARMED FORCE.

Canada.—The militia consists of all male inhabitants between the ages of 18 and 60. It it divided into four classes.

1st Class. Men from 18 to 30 years, who are unmarried or widowers without children.

2nd Class. Men from 30 to 45, who are married or widowers with children.

3rd Class. Men from 45 to 60.

The above is the order in which the male population is called upon to serve.

The Militia is divided into Active and Reserve.

The Active Militia consists of the Volunteer Militia, the Regular Militia, and the Marine Militia. The Volunteer Militia being composed of corps raised by voluntary enlistment; the Regular Militia of men who have voluntarily enlisted to serve in the same, or who have been balloted to serve; the Marine Militia composed of seamen, and persons whose usual occupation is upon any steam or sailing craft; the Reserve Militia consists of the whole of the men who are not serving in the Active Militia for the time being. The period of service, in time of

peace, in the Volunteer Militia is three years, in the Regular and Marine Militia two years. Men enrolled in the service companies of Regular or Marine Militia during any such two years are not again liable to be taken for drill and training until all the other men in 1st, 2nd, or 3rd Class of the same "company division" have volunteered or been balloted to serve. No member of a Volunteer Militia corps can, in time of peace, resign under six months' notice.

Canada is divided into 12 Military Districts; these are subdivided into Brigade and Regimental Divisions, and again into Company Divisions.

In each Regimental Division, one Lieutenant-Colonel and two Majors of Reserve Militia are appointed from the residents therein; all Militia orders and reports are sent to and received through them. In each Company Division one Captain, and one Lieutenant, and one Ensign are likewise appointed to the Reserve Militia. These are responsible by seniority to the Regimental Staff. Enrolment is carried on by Officers of Company Divisions, and the list is corrected before 28th February every fifth year; from the company returns the regimental rolls are made up. "The enrolment," for which the company Officers are responsible, is "held to be an embodiment of all the Militiamen enrolled, and renders them liable to serve, unless exempt "by law."[1]

The following, though enrolled, are exempted from active service, except in case of war, invasion, or insurrection. Half-pay Officers of Her Majesty's Army and Navy, sea-faring men, and sailors actually employed in their calling, pilots and apprentice pilots during the season of navigation, masters of public and common schools.

Her Majesty is empowered by the Act to make such regulations for the enrolment of such horses as may be necessary for the purpose of field artillery and cavalry.

The oath to be taken by all ranks of Active Militia is simply as follows:—"I, *A. B.*, do sincerely promise and swear that I will be "faithful and bear true allegiance to Her Majesty." It can be administered by the Commanding Officer.

When the Active Militia is to be organized for drill or actual service, and enough men do not volunteer in any Company Division to complete the quota required from that Division, the men in the 1st class are balloted first, if the number of men required is greater than the whole number in 1st class, then the 2nd class is required to make up the deficiency, and so on through each class; but at no time—says the Act—"shall more than one son belonging to the same family, "residing in the same house—if there be more than one inscribed on "the militia roll—be drawn, unless the number of names so inscribed "be insufficient to complete the required proportion of service "men."

Appointments of Officers to the Active Militia are provisional,

[1] Exemptions: Judges, clergy, ministers of religion, professors in colleges and universities, or teachers of religious orders, warden keepers, guards of penitentiaries, officers, keepers, and guards of public lunatic asylums, persons disabled by bodily infirmity, and "the only son of a widow being her only support."

pending the taking out of a certificate of fitness from one of the military schools of the Dominion.

According to the Act, Officers of Her Majesty's Regular Army are always reckoned senior to Militia Officers of the same rank whatever be the dates of their respective commissions.

The present law permits the training annually of a number not exceeding 45,000 of all ranks. The training period for Active Militia, called out for training, is not to exceed 16, nor to be less than 8 days in any one year.

Non-commissioned officers and privates of mounted corps receive, for each day's drill of three hours, 75 cents for each horse that has taken part in the drill; and every officer and man of the Regular and Marine Militia, and the officers of Reserve Militia, called out for training, receive 50 cents for each day's drill. Payment for drill is made on proof of compliance with regulations touching the drill and efficiency of the several corps.

The Militia, or any part of it, may be called out for "actual service," either within or without the Dominion, whenever it appears advisable to do so by reason of war, invasion, or insurrection, or danger of any of them, and when so called out, it may be placed by Her Majesty under the orders of the Commander of Her Majesty's Regular Forces in Canada, and will be paid at such rates of daily pay as are paid in Her Majesty's Service.

Officers and men, when called out for actual service, and also during the period of annual training, or during drill or parade of his corps, or as spectators, or while wearing uniform, are subject to the Rules and Articles of War and Mutiny Act, the Queen's Regulations and Orders for the Army, and all other laws then applicable to Her Majesty's troops in Canada, and not inconsistent with the Canadian Act.

Such are, I believe the chief characteristics of the framework on which Canada has raised her military organization. I beg it to be remembered that my sketch is a very crude and rough one, and quite unworthy of a subject which should be treated in a separate lecture, and demands, not only more detailed knowledge than I possess, but also a personal experience of its working, which is an honour I cannot claim.

The Reserve Militia numbers some 655,000; it is duly regimentalized, and in some measure efficient, but has not been mustered since 1873. The strength of the Active Militia is in round numbers some 43,700 all ranks.

Field Artillery—18 Batteries	1,326
Garrison „	3,048
Engineers	232
Cavalry	1,803
Infantry	37,320
	43,729

There is a Royal Military College[1] at Kingston, one School of

[1] Commandant of Royal Military College .. Lieut.-Col. E. O. Hewitt, R.E.
„ School of Gunnery, Quebec „ T. B. Strange, R.A.
„ „ „ Kingston „ D. Irwin, R.A.

Gunnery, called A battery, also at Kingston; and another, B battery, at Quebec. There are besides numerous Rifle Associations, and a Dominion Artillery Association. I venture to commend to very serious attention the Prize Essays of the latter Association (one of which will be found in the "Journal."[1]) I do so, not only on account of their great value as a contribution to military literature, but as giving some idea of the progress that Association and the Schools of Gunnery have made and are making under the able auspices of Colonels Strange and Irwin, R.A.

There is a Minister of Militia and Defence charged with and responsible for the Administration of Militia Affairs, including all matters involving expenditure. The Canadian Parliament votes, of course, the appropriation for Militia and Defence annually according to its judgment.

I shall briefly refer again to Canada in summing up my remarks, but before passing to other Colonies, it is but right to recall the fact of offers of Imperial service which in 1877-78 came across the sea from the Great Dominion. "These offers," says the official report, "some of per-" sonal service, others to raise battalions, bore the stamp of a thorough " determination to give willing and material reinforcements to Her " Majesty's troops. They were the spontaneous expressions of a loyal " and a high-spirited people to throw in their lot as a very important " factor in the destinies of Great Britain. These offers were as cordially " received by the Imperial Government as they were loyally made, and " should the occasion have arisen, no doubt but that the hardy and " stalwart sons of Canada would have been found standing manfully " shoulder to shoulder with their native-born brethren of that 'old " 'country' which they love so well.

"But withal, it would have been a question for careful thought, to " determine to what extent such a contingent should have been accepted. " It would be unwise and perhaps dangerous to denude this country " 'too largely of its fighting men.

Newfoundland.—In Newfoundland—occupying so important an Imperial position, geographically, both with respect to Canada and to England--what do we find in the way of defence? Nothing whatever, not even a militia law in force. Several volunteer companies were established some years since, with an enlistment of three years, on expiring of which term they were broken up. We handed over to this Colony some nine forts and batteries, such as they were, an ordnance yard, wharf, and engineer workshops. From 1870 to 1877, not one halfpenny has been spent under the head of military disbursements by Newfoundland. Here, then, is a specimen of the results of trusting the defence of our Empire to a Voluntary principle of "home defence." Remember that Newfoundland is a sort of uvula in the Great St. Lawrence throat through which the Dominion breathes; and weigh this fact, that it is not a part of her military system even, and she may suffer by the neglect and inability of the inhabitants of Newfoundland.

Australian Group.—In Australia there are seven different Colonies,

[1] No. 94, p. 184, *et seq.* [2] *Vide* "Report on State of Militia, Canada, 1877."

and therefore it would be utterly impossible here to describe separately each system of military organization and progress, the more especially as none of these several systems have been exactly constant quantities, many have been spasmodic, and others exceedingly variable.

Canada in 1868 founded her military system on a carefully drawn, carefully considered "Militia and Defence Act" of which I have indicated the leading principles. That Act has not been altered. The Dominion Government at once took the responsibility of providing for its military necessities and of adopting principles of organization which were obligatory on all its citizens. Australian Colonies did the reverse. They avoided the responsibility by authorizing such inhabitants as were moved by a military spirit to organize defence. It is a remarkable fact, and one o curious interest, that when Englishmen, at home, rushed to arms and formed themselves into Volunteer Corps—in 1859—they were only doing what Englishmen in the Colonies had done in 1854. When the Imperial Parliament reorganized and incorporated Volunteer Corps as a part of the Defence system of Great Britain, it was only following in the footsteps trodden years before by Colonial Parliaments in the South Pacific.

Now while Canada has been steadily developing her system, Australian Colonies have been perpetually altering theirs. There are, on the parliamentary records of these Colonies, an aggregate of nearly 50 Acts of a military and naval nature, one Colony alone having passed 20 Statutes to enable inhabitants to provide for their safety. Now this is our fault, I think, not theirs, and therefore I do not mention the circumstance for the purpose of disparaging their gallant though spasmodic military experiments which, while costing them very considerable sums of money, have in some cases produced no adequate result, and in others absolute waste. At this moment it is impossible to say—as regards *every* Australian Colony—what is the precise strength and nature of existing organizations or what are the Australians' Bills for Defence for 1877-78. It is, however, desirable to give an outline of the military system, &c., of each Colony roughly and briefly. I must premise that the facts I am about to lay before you, so far as they relate to the actual forces existing in Australian Colonies except West Australia and New Zealand, I extract from an official memorandum of June, 1878, by Lieutenant-Colonel Scratchly, R.E., now officially employed out there, not, however, by the Imperial Government but by the Australian Colonies.

New South Wales.—"In New South Wales the Local Forces are "composed of—1, A Permanent Force, raised somewhat upon the "old English army system, the defects of which are perpetuated "without any corresponding advantages. Although the Force is "almost everything that can be desired for fighting purposes, it "possesses defects of organization that must in the end prove fatal "to the maintenance of a Permament Force in these Colonies on "a satisfactory footing. 2, A naval Brigade, governed by special "Regulations under the Volunteer Act, and intended for service "afloat. 3, A Volunteer Force, enrolled on the principle of grant- "ing Land Orders for efficient service, a system which has been

"found not to give the desired result; consequently, without altering "the Act, a revision of the Regulations for the Government of "the Force has been proposed by Colonel Richardson, the Com- "mandant, in accordance with Sir W. Jervois' recommendation. "Under these Regulations continuous training for a few days "during each year, besides a certain number of drills in daylight, are "rendered compulsory in return for a money payment. This reform "will constitute a valuable experiment from which the other Colonies "should profit.

"In Queensland there is only a Volunteer Force, and the main- "tenance of a permanent nucleus has not yet been decided on. A "Bill is now before the Legislature of the Colony, which embodies "the suggestions made by Sir W Jervois.

"The Tasmanian and South Australian Permanent Forces are "about to be raised, and Volunteer Forces are being enrolled, but the "question of organization is under consideration. In South Australia, "the money payment system is likely to be adopted.

"In Victoria the Local Forces comprise—1, A Permanent Force. "2, A Naval Reserve, governed by special Regulations, but enrolled "under the same Discipline Act as the Permanent Artillery. 3, A "Volunteer Force upon the purely Voluntary principle. The Land "Order system was also tried in Victoria without any good result, "and it has been abandoned."

It is to be observed that no allusion is made by Colonel Scratchly to West Australia or New Zealand. The latter Colony declined to have the advice of Sir W. Jervois and Colonel Scratchly on the ground that it had no money to spend on precautions for external defences, and West Australia is too poor to provide any such means singlehanded. New Zealand has Militia and Volunteer laws in force, every man between the ages of 17 and 55 being compulsorily enrolled in the Militia, but actual service is limited by the bounds of Militia districts, and I believe I am correct in stating that the Militia of New Zealand only exists on paper. In West Australia there is a Volunteer Force.

The total armed strength of all these Colonies is shown in Table IX. I regret that space forbids my entering into an examination of the cost of these local isolated efforts of each Colony without a nucleus of regular interchangeable forces. My calculations lead me to conclude that they are most expensive, and that the United Kingdom and each of the Colonies are wasting money for want of common-sense business-like co-operation.

Let me, however, give you one instance in order to impress you at all events with the feeling that there is good ground for serious inquiry. Tasmania is in a general sense a position of very great importance to the Empire in Australian waters. Between 1860 and 1871 inclusive, that Colony spent over £18,000 on works, arms, and ammunition, and £27,000 on maintenance of Volunteers. That force "melted in air, "thin air," and from 1872 to 1875 no military expenditure consequently was incurred. Parliament inquiry in 1875 brought out the fact that the

Volunteer force consisted of but 28 all told, and that it had not been drilled nor inspected since 1871. The £27,000 might just as well have been thrown into the sea. Now respecting the £18,000 spent in addition on works, arms, and ammunition, I simply give you an extract from an official telegram sent from the Governor, 21 May, 1877, to the Minister for the Colonies in London. After naming guns and ammunition required, the telegram concludes thus: "I earnestly beg "help for poor Colony: strategically important: making efforts, what "you cannot give agents pay."

I have watched the military history of Tasmania in common with other Colonies, and for fear of being misunderstood, I wish to say I do not mean to imply that that waste of money was any one's fault in particular, but is the natural result of a vicious system, or rather of the absence of any Imperial system at all. During the "war scares" of 1877–78, while Englishmen at home were talking of going to Constantinople, Englishmen abroad were thinking of their lives and properties, *and of their sea trade lines;* and these cannot be injured without the Empire being seriously hurt. Besides being bound together by nationality, loyalty, and natural sentiment, we are closely knit by self-interest and trade connection; but in matters of defence, we seem to prefer to trust to fickle fortune rather than to business-like co-operation and common-sense precautions.

The Cape.—This Colony at present furnishes ample fuel for a burning question, and well it may; but the subject under consideration does not admit of our turning aside to give it special or exceptional examination. I would, however, remark that it is the only Colony Proper in which are quartered regular troops for internal defence, and that the hour is close at hand when the whole question of Colonial and Imperial responsibility as regards *internal* order and *defence* will be raised for the last time perhaps in the history of the Empire. The opening of this question will probably afford the very last favourable opportunity for calmly and deliberately considering the reciprocal naval and military duties of England and the Colonies in matters of common defence. It is most earnestly to be hoped that this fact will not be forgotten, and that in seeking in peace finality as regards internal Colonial defence, we shall not leave the far wider question of Imperial defence to settle itself, or to be settled for us, in the accidents and chances of a great war.

The history of the organization of local forces at the Cape is so simple and instructive, that it may be useful to give its brief outlines down to last year. To carry inquiry or remark further would answer no useful purpose, as exceptional causes have, too late, produced exceptional military results.

"In 1855, it was deemed 'expedient to make provision' for en- "rolling and organizing the able-bodied inhabitants of the Colony for "the protection of life and property," not, however, within the Colony, but "*within their respective districts.*"

This is roughly the preamble of the Act of that year, the salient features of which are as follows:—

1. The enrolment by districts of all male residents therein, between the ages of 20 and 50, save and except certain officials.
2. When necessary for the defence of any divisions of the Colony, the Governor was empowered to call out this burgher force for service within the said divisions and not elsewhere, except with the burghers' own consent.
3. The officers to be elected by the Force so enrolled.

No provision was made to render the Force efficient as a military body; some idea of the discipline may be gathered from the fact that absence when called out, wilful disobedience of orders, were punishable by fine *not exceeding* £3, which was the highest penalty, and was only recoverable by civil process. One year later another Act was passed, by which the inhabitants were authorized to form themselves into Volunteer Corps for the defence of their respective divisions; while it exempted such volunteers from serving in the burgher force, it made no other provision for drill, training, or discipline. With such a system the Cape drifted for over 20 years to a natural destiny of trouble. Then came war, to meet which it was created, and in which it at once utterly broke down. This is a picture in miniature of the mode and the manner in which the British Empire is now acting.

I only ask those who are annoyed with their brother Englishmen in South Africa for neglecting to provide efficiently for their defence, to remember that they only did on a very small scale what their own Empire is doing all over the world.

Last year the Acts to which I refer were repealed, and the following Acts were passed:—

1. The Cape Mounted Yeomanry Act.—This provided for a paid corps, not exceeding 3,000, to be raised by voluntary enlistment, for general military service within the Colony or beyond the border thereof, wherever the interest of the Colony may require. Officers to be appointed by the Governor.
2. The Burgher Force and Levies Act, which provided for the enrolment of every male between 18 and 50; it perpetuates the system of electing officers; it empowers the Governor to call out the Force for inspection and rifle practice, as he may direct; and also for actual service. The extreme penalty for absence or for refusing to obey orders when called out is £2, or in default 14 days' imprisonment.
3. The Volunteer Act empowers the Governor to accept services of naval and military volunteer corps, and to make regulations for constitution, pay, and discipline. All Forces created under these Acts are liable to service "within the Colony or beyond the "borders thereof." No annual system of training is provided, nor would any of the corps be under the Mutiny Act, even when on actual service. Now all these Acts have been passed subsequent to the publication of a memorandum by Sir Bartle Frere containing the following extract:—"I feel assured a Militia on "the English plan would be found more efficient and less "expensive than any other force of the kind which has been

"recommended by writers or speakers on the subject."[1] I draw your attention to the fact that Sir Bartle Frere's opinion is not the basis on which the defensive system of the Cape is framed.

Natal.—It may be useful to treat Natal in the same manner as I have done the Cape. In 1854 a Volunteer Ordinance was framed which made it lawful for persons, with the sanction of the Governor, to form themselves into Volunteer Corps, to elect their own officers, and to make their own rules. Such Volunteers to be exempt from being compelled to serve in any Militia or military force which might be raised, and no corps could be compelled to serve at a greater distance than 30 miles from its own head-quarters. This Ordinance was repealed next year, and another Act was passed, in its general principle perpetuating the same system.

I will pursue inquiry no further with regard to the Cape and Natal for fear of confusing between the details of defence in one Colony and general principles applicable to all.

The total Volunteer strength of the Cape on the 31st December, 1877, was 3,343, of Natal 644, all ranks. At the Cape the force was armed with four different pattern rifles.

I am obliged to leave out all reference under this head to Plantation Colonies and Trading Settlements. I do so with regret, for the history of spasmodic local efforts and their results would bring to notice some very extraordinary facts, of great importance in the general question.

Before concluding this review of purely military Colonial organization there is one most important aspect of the principle on which we are now acting which must not and cannot be overlooked. No matter what may be the true value of the Colonial developed resources as regards numerical military strength, when weighed in the scale of Imperial necessity for united action and a common plan, such strength is absolutely useless unless properly armed and supplied with ammunition and military materials.

When we adopted fragmentary systems of Home Defence and Local Self-Reliance as the cardinal principles by which our Empire was to be defended, we made no regulations whatever and no provisions whatever for providing for the supply of arms and munitions of war to the Colonies.

We left the question to drift, and it is drifting still. The question cannot be shirked nor avoided by saying the Colonies must be self-reliant and buy them, for it really covers a very wide field. It not only concerns the distant positions of our Empire, but enters the very core of our supply system at Home. As the Colonies pay for what they want and they expect to get at once and at all times what they require, the question is, *are we prepared to supply them when these demands are largest and most urgent, which will also be the hour of our sorest need?* If any such calamity happened as a rupture with America—which I say, God forbid—could the Arsenal at Woolwich with the strain then thrown upon it meet in addition the requisitions of the Canadian army number-

[1] See Memorandum, 26th December, 1877, "Cape Parliament Papers."

ing 600,000, and also the demands of Australasian and Plantation Colonies and Military and Trading Settlements, all pouring in at one and the same time?

This is an extreme case, but during the scare of 1877–78, from numerous Colonies came constant telegraphic demands for various descriptions of stores, and if they come thick at such a time, they will come by hundreds when war is declared. We have done nothing whatever to prepare for meeting promptly the enormous extra demands on Home supplies caused by the fluctuations and the growth of military forces in the Colonies. Now the principle of individual self-reliance on the part of each fragment of the Empire involves not only choice as to what defensive organization each adopts, but also the exercise of a free and independent judgment in the selections of weapons and stores. Hence it is that it places Home arsenals in the position of not knowing from hour to hour what is the precise nature of the stores Colonial Governments may demand through the diverse channels of departmental communication. Want of uniformity, produced by absence of a common or Imperial system of defence, renders it utterly impossible to regulate supply efficiently and economically. I cannot extend my remarks further on this head, but when they are considered in a business-like practical manner in conjunction with the broad fact that British fleets and military forces all over the world are, by our present system, compelled to rely mainly on Home arsenals, I think my humble opinion will not be found far short of the truth. It is briefly this—that the Imperial supply system will utterly break down under the strain of war.

Before turning to naval Colonial organization, let me shortly state the exact point at which the most progressive Colonies have now arrived. Canada is finding out that a permanent nucleus of military force is a necessity. For further information I refer you to the latest official report on the state of the Militia of the Dominion. Victoria and New South Wales have for some years each had a permanent local military artillery force. Now we abolished local military forces of the Royal Army because experience had proved the principle to be full of defects. Canada seems to be aware of this, for the plan proposed for consideration is to make the small nucleus of three battalions interchangeable with battalions of line in England. It is neither necessary, nor is it now possible, for any Colony of Australia to adopt this system on such a scale, because the permanent military forces required to be maintained are small. But if the local forces in Australia are supplementary to naval defence, each nucleus should be adapted to the requirements both of Australian Governments and also to naval power. The practical difficulty of Imperial interchangeability vanishes if the Marine Artillery and Marine Infantry cease to be overlooked. Their organization makes it a matter of indifference whether they have to send a corporal's guard to Botany Bay or thousands to Gallipoli. The Australian Governments must have a guarantee that such nucleus must not be withdrawn in war, and while they bear the cost of their nucleus we must bear the cost of maintaining a corresponding number of their forces at home, treating them in all respects as part and parcel

of the Royal Forces, with equal claims as to rank, rewards, and emoluments. The system of the Marine Artillery makes it a matter of indifference whether its members are called on to instruct naval reserves in gun drill or military forces in all branches—except cavalry and engineering—of military art, and I think inquiry would show this plan, suggested many years ago, would be more economical to Australian Colonies and not more costly to England than the system now pursued, and would pave the way for that welding together of English war-power of defence into "one harmonious whole," for which we should all earnestly strive.

I conclude this portion of my subject by stating that the aggregate annual revenue of the Colonies is now nearly 27 millions, the aggregate annual value of their exports and imports about 200 millions. The revenue has therefore increased thirteen-fold, while the annual value of exports and imports is six times what it was when Her Majesty began to reign.

"Naval Armed Strength and Organization."

Under this head I have, as regards Canada, nothing to bring to your notice, except the absence practically of any naval system at all: I desire, however, to draw attention to the fact that—so apathetic are Englishmen now about naval affairs—it has remained for a military Officer, Sir Selby Smyth, to urge upon the Canadian Government the adoption of a system of co-operation with the Royal Navy. According to the last Canadian census there are some 16,000 persons whose calling is the mercantile marine; and by Mr. Keefer's excellent handbook it appears there are nearly 53,000 men employed in the Fisheries.

Victoria possesses the "Cerberus," a harbour-defence ship, and the "Nelson," a sea-going wooden vessel. Considerable alterations have been made in this latter vessel within the last year, and, to the credit of the Colony be it said, without calling in external aid. The Victorian Act of 1870 provides "that armed vessels maintained by "the Colony shall be for the purpose of defending the Coast of "Victoria and co-operating, in time of war, with the ships of the "Royal Navy, in such manner as the Governor, *with the advice of the "Executive Council, shall approve.*"

So far back as 1855, New South Wales passed an Act for maintaining "armed vessels for the service of the Colony, for the protection "thereof, and for other purposes." Now, with full knowledge of the loyalty and patriotism of Englishmen in the Colonies and their liberality as regards expenditure on defence, I cannot think that in the hour of danger, which will also be a time of popular excitement, Executive Councils will be allowed to permit their armed vessels to extend operations beyond the maritime league. Herein lies a source of danger. The Admiralty at home is tolerably certain to regard each Colonial armed vessel as a source of British Naval strength in Australian seas, and to take credit for it in the estimate of required power, while the Commodore, in those waters, must make his dis-

position of naval force, which he nominally commands, not in accordance with the necessities forced upon him by the mode of impending attack, but by the views and wishes of different Executive Councils, controlling portions of his fleet. The annual value of exports and imports of Australasian Colonies approaches now 100 millions; of this, over 40 millions passes and repasses to the United Kingdom, and it is difficult to conceive a more dangerous naval principle than that which we are now fostering and nourishing in the bosom of Australian seas.

The principle of localizing the action of naval force, whether it be by Acts of Colonial Parliaments, by ships that cannot keep the sea, or by immobility of military forces intended to act in the support of our fleets, to my mind contains the germs of creeping naval paralysis, which, if not checked, will prostrate and finally destroy our supremacy of the sea.

The naval force of Victoria consists of permanent "*Cadres*," numbering 119, maintained on board their two ships, and a naval reserve of 229, which receives a retaining fee to hold itself in readiness to complete the complement of the "Cerberus" and the "Nelson." These vessels' complements would be under the Naval Discipline Act when called out for actual service.

In New South Wales there is a Naval Volunteer Brigade, numbering some 286, and in New Zealand there are five Naval Volunteer Corps, with an aggregate strength of 431. The developed naval resources, therefore, of the mercantile marine of the Colonial Empire—which is by half greater than that of France—consists of one harbour defence vessel, one wooden vessel, and a handful of Volunteers, some of whom are wholly uninstructed and others certainly undisciplined. According to the census returns, there are more than 10,000 persons in Australasia whose calling is on the sea; the number at the Cape is infinitesimal.

Captain Marshal Smith, Master of the Australian Barque "T. T. "Hall," writing to the "Nautical Magazine," from the other side of the world, says: "It has often surprised the writer that in all the "recommendations for defence, a Colonial Naval Reserve has never been "proposed until Mr. Brassey's proposition." He calculated "that 2,000 "Australian seamen might be trained and organized as a reserve for "the Royal Navy." Englishmen, however, seem blind to this Colonial resource and deaf to the utterances of a General in Canada and to the pleadings of a Colonial Merchant Captain at the Antipodes.

Conclusion.

Time compels me to refrain from summing up these two papers in a manner worthy of the subject. I cannot conclude, however, without once more entreating the men who have the power, to obtain inquiry into the workings of our present policy of Imperial defence, which has now been in force for a period approaching ten years. I incline to the belief that it is breeding a series of naval and military confusions; but I sincerely hope I may be wrong. Such an inquiry, I

venture to think, must take the form of an Imperial Commission on which should sit representatives of the great Colonies, selected by them for the purpose. This Commission should have an advising Council of naval and military authorities, to inquire into and to fix the principles on which the Empire must act, in order to secure the maximum amount of safety at a minimum cost. It is a past hope that the great Colonies will ever now join in a general scheme, in the construction of which they have had no voice, and in the carrying out of which reciprocal duties and obligations of defence are not clearly defined. " Spreading, as the Empire is, over every part of the habitable " globe it is," says Mr. Frederick Young,[1] " of the utmost importance " to inquire by what means its permanent union may be most effectually " secured." Now I take it that all Englishmen are agreed on that point, and its naval and military bearing is this:—" *It is of the utmost* " *importance to scientifically* ' *inquire* ' *by what means Imperial safety in* " *war* ' *may be most effectually* ' *and economically* ' *guaranteed.*' "

This we have not yet done.

Having launched our Empire on military and naval planks of self-reliance without any union or any bond, we hope it may drift into a haven of safety; and we or those who come after us may find it stranded amidst the breakers of mutual mistrust.

It is said that the question of Imperial Defence is too big to inquire into as a whole. Well, the Empire is getting bigger and bigger every day, and if we fear to face the problem now, what have we to hope for in procrastination and delay?

We stave off the duty of calm, deliberate, inquiry by vague phrases respecting our " supremacy of the sea." We surely ought to inquire and clearly define by what method and on what broad principles that supremacy is to be maintained.

This we have never yet done.

Since the introduction of steam revolutionized naval warfare, we have had no National Inquiry to seek out and define the grand principles of naval policy which can be implicitly trusted to rule supreme over every branch and part of our national naval system.

Groping amidst the *débris* of microscopic manipulations and elaborate naval details, the nation has vainly hoped to stumble across Imperial naval principles, and it now finds itself hopelessly confused as to what are great naval principles, and what are—however big—mere details. This has produced national weariness and apathy in naval affairs, and it may end in the decadence of national naval spirit. Even the English mind cannot be interested in what it cannot comprehend; and once national interest in naval affairs passes into a certain stage of deadly dull disregard, we may well look at our Imperial future with dismay. It was a national naval spirit won our Empire in the past, and must be its hope and confidence in days to come. There are signs now that military longings are—in the popular mind—supplanting naval enthusiasm, and therefore I think the time has come for such a full and searching inquiry as shall cause the English race to pause and reflect upon the practical, real necessities of their Imperial position.

[1] " Imperial Federation," by Frederick Young.

If we drift much longer we know not whither, we shall end we know not where.

Between fatal centralization on the one hand, and false localization on the other, stands the "supremacy of the sea" in the chill cold shade of national negligence: we may well look at it in hesitating doubt, as without close examination it is hard to say if it be a reality. It may be no more than a dream of the past; without inquiry we cannot say. We know it was with us in 1805, we know for certain but little else. For aught we know, the flag lowered to half-mast in the Bay of Trafalgar may have meant more than the death of a hero and apostle. It may have symbolized the decline of the cause for which he fought and the doctrine for which he died.

For all we really know of the future conditions of naval war, "our "supremacy of the sea" may be "pigeon-holed" with the papers of the Treaty of Paris or buried for ever in the crypt of St. Paul's.

NOTE.—With reference to statement, page 443, to the effect that New Zealand "declined to have the advice of Sir W. Jervois, on the ground that it had no money "to spend on precautions for external defence," it is desirable to say that the assertion was based on New Zealand Parliamentary Paper, A 6—1877, in which Government stated "They might, with little warning, have to make provision for resisting an "internal enemy," and that "the state of the finances of the Colony at present is "such, that it is their duty to avoid expenditure on public works for the defence of "the many harbours of the Colony."

Sir Julius Vogel (Agent-General) has, however, very kindly and very properly drawn my attention to the erroneous impression my words may convey, and informs me that :—

"The Government had a report from Sir W. Jervois, which that distinguished "Officer prepared in 1871, showing the defences required for the principal ports "of New Zealand. Therefore the Government did not consider it necessary to "ask Sir W. Jervois and Colonel Scratchly to visit the Colony. The report "referred to was sufficient to enable the Imperial Government to make specific "recommendations to the Colonial Government. The latter at once accepted it, "and undertook the entire cost; and the armaments, &c., for the purpose are now "on their way to New Zealand."

TABLE No. I.

Colonies Proper.

Group.	Subdivisions.	Area. Square miles.	Group Area. Square miles.	Population 1876.	Group Population.	Non-European Population.	Group Non-European Population.
Canada ..	Dominion	3,372,490	3,412,490	3,686,096[1]	3,847,470	44,531[1]	45,151
	Newfoundland ..	40,000		161,374[3]		620[3]	
	New South Wales. ..	323,437		629,776		19,219[1]	
	Victoria	88,198		840,300		34,858[1]	
	South Australia ..	903,690		213,271		..[2]	
Australasia	West Australia ..	1,057,250	3,173,310	26,709	2,401,715	102	86,797
	Tasmania	26,215		105,484		2,184	
	New Zealand ..	105,000		399,075		13,285	
	Queensland	669,520		187,100		17,149	
	Cape Colony.. ..	199,950		720,984		484,201	
	British Kaffraria ..	3,463		86,201		86,201	
	Basutoland	8,450		127,700		127,700?	
Cape ..	Fingoland and Nomansland ..	5,000	366,605	140,000	1,745,674	140,000	1,424,960
	Griqualand West ..	16,632		45,277		20,000	
	Transvaal	114,360		300,000		264,000	
	Natal..	18,750		325,512		302,858	
	Totals ..				7,994,859		1,556,908

[1] Census 1871. [2] No Returns. [3] Census 1875.

TABLE No. II.

Plantation Colonies.

Group.	Colony.	Area. Square miles.	Group Area. Square miles.	Population 1876.	Group Population.	European Population.	Group European Population.
West Indies ..	Bahamas	5,390	96,351	39,162	1,279,091	6,500	68,190
	Guiana	76,000		193,491		15,000[1]	
	Honduras	7,562		24,710		377	
	Jamaica .. .. and Turk's Isle	4,193		506,154 4,723		13,101 272	
	Leeward Isles ..	655		117,583		5,886[1]	
	Windward Isles ..	797		283,630		22,054[1]	
	Trinidad	1,754		109,638		5,000[1]	
Eastern ..	Mauritius	713	25,415	329,754	2,735,041	108,534	126,816
	Ceylon	24,702		2,405,287		18,282	
	Totals ..		121,766		4,014,132		195,006

[1] There being no official returns distinguishing white from coloured population, these figures are taken from a Table compiled by Dr. J. Forbes Watson.

TABLE No. III.

Military and Trading Settlements.

Imperial Line.	Station.	Area. Square miles.	Group Area. Square miles.	Population.	Group Population.	European Population.	Group European Population.
Canadian							
Canada and West Indian ..	Bermudas		19		12,121		4,725
	Gibraltar	$1\frac{7}{8}$		20,936			
	Malta	119		141,918			
Australasian, *viâ* Suez..	Cyprus	2,288	2,420	14,764	200,336		
	Perim	7		211			
	Aden	5		22,507		209	209
	Straits Settlements ..	1,445		308,097		1,730	
China Extension ..	Labuan	30	1,506	4,898	437,193	50	9,305
	Hong Kong	31		124.198		7,525	
Australasian and Canadian ..	Fijis		7,403		142,000		1,683
	W. Africa Branch: Gambia ..	69		14,190		57	
	W. Africa Branch: Sierra Leone	468		37,089		107	
Cape	W. Africa Branch: Gold Coast	6,000	6,691	408,070	527,638	70	5,545
	W. Africa Branch: Lagos ..	73		62,021		94	
	Ascension	34		. 27		27	
	St. Helena..	47		6,241		5,190	
Cape and Aden	Seychelles..			13,095		?	
Cape and Australasian ..							
Australasian, *viâ* Cape Horn..	Falkland Isles		6,500		1,114		1,110
Total ..					1,320,402		22,815

TABLE No. IV.

Food.

Abstract Table showing principal Articles of Food imported into the United Kingdom 1877, distinguishing, as far as possible, those from India, the Colonies, and Foreign Countries.

Living Animals (Number.)

Nature of Food.	India.	Colonies.	Foreign.	Countries not specified, &c.	Total.
Live animals	..	18,495	1,045,949	30,838	1,095,282

Meat, Fish, Grain, Meal, and Flour. Rice, Butter, Cheese, and Potatoes, in Cwts.

Nature of Food.	India.	Colonies.	Foreign.	Countries not specified, &c.	Total.
Meat and fish	..	520,757	4,917,228	35,719	5,473,704 cwts.
Grain, meal, and flour	6,103,585	7,363,595	110,761,828	399,185	124,628,193 ,,
Rice	6,251,074	..	293,578	72,951	6,617,603 ,,
Butter, cheese, and potatoes	..	418,403	10,440,528	397,232	11,256,163 ,,
Total cwts.	12,354,659	8,302,755	126,413,162	905,087	147,975,663 ,,

Tea, Coffee, Sugar, and Cocoa.

Nature of Food.	India.	Colonies.	Foreign.	Countries not specified, &c.	Total.
Tea, lbs.	30,940,724	..	156,464,403	110,157	187,515,284 lbs.
Coffee, cwts.	159,932	894,391	549,918	4,041	1,608,282 cwts.
Sugar, cwts.	891,013	5,091,978	14,047,260	20,546	20,050,797 ,,
Cocoa, lbs.	..	8,171,088	8,871,115	14,161	17,056,364 lbs.

TABLE No. V.

COMPARARATIVE STATEMENT showing Export of British Coal, distinguishing Home and Colonial, from 1854 to 1877 inclusive.

Year.	New South Wales. Exports.	Canada. Exports.	Total Colonial.	United Kingdom. Export.	Total Export. Home and Colonial.
	Tons.	Tons.	Tons.	Tons.[1]	Tons.
1854	59,297	Returns not given in Statistical Abstracts.		4,309,255	
1855	61,484			4,976,902	
1856	84,086			5,879,779	
1857	96,565			6,737,718	
1858	113,618			6,529,483	
1859	174,195			7,006,949	
1860	233,877			7,321,832	
1861	207,904			7,855,115	
1862	308,782			8,301,852	
1863	298,337			8,275,212	
1864	372,601			8,809,908	
1865	383,270			9,170,477	
1866	541,215			10,137,260	
1867	473,666			10,565,829	
1868	548,187			10,967,062	
1869	595,795			10,774,945	
1870	578,564			11,702,649	
1871	565,782			12,747,989	
1872	670,802	322,283	993,085	13,198,494	14,191,579
1873	774,029	404,757	1,178,786	12,617,566	13,796,352
1874	874,143	418,357	1,292,500	13,908,958	15,201,458
1875	928,358	288,176	1,216,534	14,475,036	15,691,570
1876	870,653	284,279	1,154,932	16,255,839	17,410,771
1877	915,727	249,536	1,165,263	14,880,899	16,046,162

[1] This Column is taken from a statement in "Coal; its History and Use."

TABLE No. VI.

Showing Destination of British Coal—in Tons—Exported in 1877.

From	To						
	Channel Isles, &c.	India.	Colonies Proper.	Plantation Colonies.	Military and Trading Settlements.	Foreign Countries.	Total.
United Kingdom	66,550	562,376	239,395	285,366	907,944	12,819,268	tons. 14,880,899
New South Wales	..	24,629	563,757	4,789	93,388	229,164	915,727
Canada	..	..	47,321	2,295	..	199,920	249,536
Total ..	66,550	587,005	850,473	292,450	1,001,332		
Grand Total ..	2,797,810					13,248,352	16,046,162

TABLE No. VII.

Horses.

Group.	Subdivision.	No. of Horses.	Total.	Date of Return, and Remarks.
Canada	Dominion	862,072	866,129	Census 1871, Province of British Columbia not included.
	Newfoundland	4,057		Census 1875.
Australia	New South Wales	366,703	958,982	
	Victoria	194,768		
	South Australia	106,903		
	Western Australia	33,502		
	Tasmania	23,622		Return 1876.
	New Zealand	99,859		Census 1874.
	Queensland	133,625		
Cape	Cape Colony	205,985	205,985	
	British Kaffraria	?	..	No reliable information.
	Basutoland	35,357	35,357	
	Fingoland and Nomansland	11,723	11,723	
	Griqualand West	?	..	do.
	Transvaal	?	..	do.
	Natal	22,722	22,722	

TABLE No. VIII.

TABLE showing Shipping belonging to British Colonies and Possessions, 31st December, 1877, and distribution thereof.

Class.	Group.			Total.	
	Name.	Vessels.	Tonnage.	Vessels.	Tonnage.
Colonies Proper	Canada	7,568	1,211,451		
	Australasia ..	2,311	245,464		
	Cape[1]	57	6,271		
	Total Colonies Proper			9,936	1,463,186
Plantation Colonies	West Indies ..	1,200	70,662		
	Ceylon	248	16,476		
	Mauritius ..	99	8,770		
	Total Plantation Colonies			1,547	95,908
Military and Trading Settlements	Europe { Gibraltar, Malta .. }	207	26,455		
	Straits Settlements	469	54,585		
	Hong Kong ..	66	20,934		
	West Africa ..	96	2,996		
	Falkland Isles ..	7	423		
	Total Military and Trading Settlements ..			845	105,393
	Total Colonies and Settlements			12,328	1,664,487
	Empire of India			187	69,481
	Total Colonies, Settlements, and India ..			12,515	1,733,968
	Shipping of United Kingdom			25,733	6,399,869
	Total British shipping			38,248	8,133,837

[1] St. Helena included.

NOTE.—Shipping returns have not been received from Melbourne since 1855, nor from twenty-two other ports abroad for 1877. The above Table, therefore, probably understates the actual number of vessels and aggregate tonnage,—*Vide* Annual Statement of Navigation and Shipping of the United Kingdom for the year 1877.—Parliamentary Paper C–1,999, 1878.

TABLE No. IX.

STATEMENT OF BRITISH LOCAL ARMED STRENGTH (*all ranks*) OF AUSTRALASIA.

Colony.	Permanent Forces.		Volunteer Forces.		Volunteer Signal and Torpedo Corps.	Total.	Remarks.
	Naval.	Military.	Naval.	Military.			
New South Wales ..	..	358	286	2,648	46	3,338	Exclusive of Public School Corps of 1,157.
Victoria	119	195	229	3,960	30	4,533	
South Australia ..	..	..	..	725	..	725	This Corps has only just been re-organized. There were no Officers in 1877.
West Australia ..	..	..	..	361	..	361	
Tasmania	..	..	Reorganizing.		..	..	
New Zealand	..	..	431	4,004	..	4,435	Exclusive of Cadet Corps of 1,710.
Queensland	..	..	..	1,094	..	1,094	Exclusive of Cadet Corps of 150.
Total ..	119	553	946	12,792	76	14,486	

First Day's Discussion.

The Chairman: It is now my duty to invite remarks on the paper that has been read. Captain Colomb has done the Institution the great kindness of undertaking to read two papers on these very important subjects. In his present paper he has dealt chiefly on the importance of our resources beyond the seas in any great scheme of national and imperial defence. I am quite sure we shall all accept that proposition, and probably very few of us can add materially in an impromptu speech to the immense accumulation of facts which go to establish the importance of those resources, and which have been put before us in Captain Colomb's paper. At the same time I am quite sure that any thoughts on those subjects which may occur to speakers will be very acceptable. With regard to the means by which these immensely valuable resources can be utilised, and the means by which they may be protected against the arms of a hostile power, Captain Colomb has not pretended to exhaust that subject in the present paper. I judge from the syllabus I hold in my hand that Captain Colomb will deal very fully with that subject in his next paper. With this explanation, I invite gentlemen to address the meeting.

Colonel Strange, R.A.: Mr. Chairman, I have been asked to say a few words. Should you think those few words of any value, I will do so, though there is a saying, that "fools rush in where angels fear to tread." The able lecturer opens his remarks by suggesting that all his exceedingly valuable calculations, the immense researches which he has made, were of no practical application until the question had been considered—what was to be done in the matter of the powers that hold in control these various sources of war material? these are the Legislatures of the different Colonies. Now how far a soldier in a military institution is allowed to touch on political subjects, I am not prepared to say. I feel that I am going on dangerous ground; but I should not be a soldier if I did not go there when I thought it my duty. We must not forget that though the Colonists have a burning loyalty—I can find no other word for it—at the same time they never cease to be Englishmen; and although they cross the Atlantic, they never altogether lose sight of their rights. They pay for their own Militia; and as Englishmen they must be consulted in the handling of it. On the other hand wars cannot be carried on successfully with a "multitude of councillors," in spite of what the wisest of men said. He was not alluding to war operations, I believe, when he made the statement that "in the "multitude of councillors there is wisdom." My alluding to this subject would be useless if I did not suggest what I consider a remedy. The remedy I have to suggest is one which has no doubt occurred to all of you: that is to say, some species of Imperial Council with representatives from the Colonies, in which questions of peace and war, as well as questions of tariff, should be considered. It has been the genius of the Anglo-Saxon race (we are often told) *to drift. We drifted* into Empire in the East. Our Clives, and our Warren Hastings', built up that Empire! We drifted out of Empire in the West, when we lost the 13 Colonies on a question of tariffs. It is perhaps an unpleasant subject to contemplate; but I believe I should not be doing my duty if I did not point out that it is a subject which must be faced, and which will not be solved by believing that dangers do not exist because we do not choose to see them. Looking at the present genuinely loyal feelings of the Colonists, I do not believe that there will be any great difficulty in this matter. Twenty years hence, the question will be a very different one; because you will be asking them to retrograde. Already the Colonies, wrongly or rightly, are beginning to think that their infant manufactures require certain protection. Is there no means of coming to an agreement? Is it not possible, in an Empire which contains every possible want and need of man, to form a tariff, an agreement which shall be beneficial both to the mother-country and to the Colonies? I am not a commercial man; but let me just take one point. Free trade in timber, and the opening of English ports to Baltic timber, were severe blows to Canada. Supposing, then, that was reversed, and that Canadian timber was allowed into England on favourable terms as compared with Baltic timber, it would be an enormous boon for Canada, and as a *quid pro quo*, English goods

should be introduced duty free into Canada, where they are already putting a duty against American goods. If that is carried out to a further extent, English goods could be received in Canada, American goods having a differential duty against them. I have no doubt I shall be immediately met by saying any species of representation, or any kind of Council, is almost an impossibility. What basis will you have it on? Not on the basis of population. The lecturer has already told you that Canada, with an area once and a half greater than that of European Russia, has a population only equal to London. On what, then, will you base it? On the revenue which each Colony is willing to give towards Imperial purposes. You then have the Transatlantic Englishman on fair terms. He cannot complain of insufficient representation, because the answer is, "If you want more votes in the "expenditure of that money, contribute more towards it." You will not find, I think, an overwhelming number of Colonial representatives in your Federal Council, because the generality of Colonists are struggling to develop their own country, and they scarcely are aware of the enormous results at stake to the Empire generally. They have a general feeling of loyalty, and would not be inclined to cavil at the arrangements that had been made in those respects. There is no necessity for my attempting further to supplement the lecturer, because his facts and figures are such that they are unanswerable. You will therefore excuse me for having occupied your attention for these few minutes.

Colonel ALCOCK: May I be allowed to say a word or two upon the subject under discussion, although it may be thought, perhaps, rather trivial to introduce them? The last speaker has referred to the possibility of obtaining revenues from the Colonies for Imperial purposes, and our excellent and able lecturer, in the commencement of his paper, has given us the facts and the principles upon which he argues; but I do not think it has been stated that this matter is exclusively with reference to Colonial defence. Foreign writers, in looking upon the great extension of our Empire, attribute that extension to the Chauvinistic feeling of the people, and to an Imperialistic desire for more extended rule. That is their idea, which we, of course, all know perfectly well to be totally opposed to the universal opinion of the nation, which would reject an unnecessary extension of the Empire, as being conducive to unnecessary war. Now our subject is the preparation for war; but that only for self-defence. It must be admitted, of course, that the extension of our Empire has been forced upon us, and may at any time be forced upon us to a still greater extent, and for this reason—that we are conterminous with hostile or barbarous tribes, which are liable at any time to bring on a war; but it must be understood, of course—and it should be understood by foreigners, especially—that with us a war is, as it ought to be with all nations, a war of necessity and a war in the furtherance and progress of civilization, and of course carried on with humanity. In another part of the lecture there was an allusion to the possibility of the Empire being attacked through her Colonies, and nothing can be more evident than the importance of this, because if you have a hostile people upon your frontier ready for aggression, and those people are not controlled or suppressed, the consequence will be that the Empire will be in exactly the same position as that in which Continental countries are at present placed, where the enormous development of military power in one obliges a similar development upon the part of all—a state or condition which it must be our object to avoid. Much more might be said upon these subjects, but being foreign to the details of the lecture, to do so would encroach upon the time which will be, by others, more appropriately employed.

Mr. YOUNG, Honorary Secretary Royal Colonial Institution: I do not know what impression has been made on others who are present, but I must confess for myself I feel that the paper we have heard to-day is a very remarkable one. Of all the questions that can be brought forward before this Institution, none can be of more importance than this. In the opening paragraphs an allusion has been made to a very important part of the subject, which is hardly, perhaps, within the cognisance of this Institution, excepting in one way; that is, that naval and military men are, as Englishmen, interested in the solution of what we call the stupendous problem which will one day have to be faced by this country. Captain Colomb draws our attention to four different points connected with the naval and military resources of the Colonies: first, men; second, food;

third, coal; and, lastly, horses. I think, with regard to the first point, that of men, that although he has shown us that we have an almost practically illimitable supply of the raw material; although he has, very properly, left out of consideration the various native populations which form part of the British Empire, still, one of those sources might have been alluded to more prominently. I refer to the Maories of New Zealand. It may, perhaps, be only as a compliment that we find in our army-lists the names of some of the New Zealand chieftains as officers of the British Army; but as time goes on, and that part of the Empire develops itself, I cannot help thinking that that noble and intelligent race of aborigines will very likely become an element of future support to the British Empire. Next, with regard to food, the whole question hinges on the importance of our finding proper protection for our food supplies, on which we shall be more and more dependent in future. We must look to our Colonies more and more for supplying us with the food we are to eat; and in order to take care we are not starved out, we must protect our lines of communication between the distant parts of the Empire and the home country. How are we to do this? By having proper naval stations, efficiently protected, to insure us, that under all circumstances, we shall have these food supplies regularly brought to us. Coal is another most essential element to which Captain Colomb has referred; and it must be of the greatest importance that we should take care, having a practically illimitable supply all over the world, of the different points from which we may obtain that most important war material, to guard them from any possible attack, and make them inviolable in case of war. The fourth point, that of horses, is again a most important one; and it can scarcely be questioned, that if we foster in the different parts of the Empire the development of that raw material in the way we ought to do, we may have a most powerful addition to our strength in time of necessity. I hope that the time has passed, never to return, in which it will be imagined that the mother-country can do without the Colonies, or, on the other hand, that the Colonies can do without the mother-country. I think a better and less insular spirit has prevailed of late years, and I hope that it may continue. For the benefit of humanity, of civilization, of their mutual self-interest, and common good, it is an absolute necessity that the unity of England and her Colonies should continue to be maintained. The only problem, and a very stupendous one it is for us to grapple with, is, as to the best means by which that union can be established. I think we are all deeply indebted to Captain Colomb for having brought this particular portion of the subject before us in the thoughtful way he has done, in the admirable paper which we have heard; and I heartily trust its effect may not be confined to this audience alone, but that it may go forth and bear fruit throughout the length and breadth of the British Empire.

Admiral Sir Spencer Robinson: I should like to say a few words on this discussion. The question has been asked, "Are we going to drift into this or that?" There is one particular thing which I think all of us must have noticed—how thoroughly the lecturer made evident that it was the duty of all of us, as far as we possibly could, to have a policy and enunciate it upon a matter of such extreme importance as that which he has brought before us. Of all the misfortunes which could happen to a great Empire no greater misfortune can happen than that of being without a policy and that of drifting by the tide of popular ignorance or the tide of misunderstood self-interest into places from which there can be no exit. The policy of the British Empire is one of such magnitude that to discuss it in this hall would be improper and inexpedient, but we may say that every man who has heard this lecture to-day is in a certain measure responsible if he does not by every means in his power impress upon those who do manage this vast Empire that they must have a policy, and that policy is to develop in the largest Empire ever united in the grasp of one country all the resources, all the wealth, all the civilization, and all the happiness which, great as are its possessions and vast as is its power, only a wise policy will enable us to secure. We are not without duties, we are not without responsibilities, and those duties and those responsibilities increase and multiply in proportion to the greatness of the Empire with which we are connected, and to the glory of the inheritance we have received from our forefathers. I for one can only say it is with feelings of the greatest gratitude to the lecturer and of the greatest delight that I have been present to-day, and have heard something which I cannot but think must

bring forth some good, and which will, I have no doubt, fructify in the mind of everybody who has had the good fortune to hear it.

Mr. Robert Webster: There are only one or two remarks I should like to make, and those are with reference to the food supply. The lecturer pointed out that out of the total population of this country 15,000,000 are supplied by American grain. Now if one looks at that Table No. IV, one sees that from foreign countries in 1877, there were imported 110,000,000 quarters of grain, meal, and flour, whereas from the British Colonies there were only imported 7,000,000. That seems to me to show that this country is in a rather dangerous position, especially remembering that of the 110,000,000 we get the greater proportion from America and Russia. Presuming that we are at war with either of these countries, can our Colonies, presuming the communication is right, supply us with sufficient grain to keep the population of this country alive? Could we get it from Hungary, or France, or in fact, if the grain supply was cut off from America and Russia, should we be able to exist as a nation? That is an important question. Of course the only way in which we could have a grain supply from our Colonies would be by their being more inhabited, and by encouraging, if we possibly could, our soldiers and sailors when they leave the Service to become Colonists, giving them farms also in addition to deferred pay. The only question is, Will sailors and soldiers make good Colonists, would they know anything about farming, and would they become a useful portion of the population of those Colonies?

Mr. Strangways, late Premier of Victoria, New South Wales: I think I could partly answer the question put by the preceding speaker, and I may say from my own knowledge in Australia that a very large number of men who have been soldiers do make very good Colonists; there are a very large number of men in the Australian Colonies who have been sailors, and who have made and do make extremely good Colonists. And my personal experience is that, speaking generally, no man makes a better Colonist than a man who has been a sailor; he is a handy man, and can do almost anything. I had a man in my own employ who had been a sailor, and he could do anything except ride a horse or drive a team of bullocks. Those two qualifications, I think, are not absolutely essential in a good Colonist. The gentleman who opened the discussion alluded to the most important point affecting the whole of this question, and it is somewhat interesting to find that, although when you get into places where your words go into the public press, amongst those intelligent persons who are sometimes called penny-a-liners, if you venture to allude to the word Empire, you are at once denounced as a "Jingo;" still when you come amongst men who have large personal experience, the very first point in connection with the question that commends itself to their practical experience is that very question of Imperial unity. The whole question raised by Captain Colomb is embraced in the first part of the lecture, namely, the difficulties in the way of consolidating Imperial or national (in a wide sense) war power. If you call upon the Colonies to join with England in the general defence of the whole Empire, are you prepared to give those Colonies a voice in the question of peace and war? That is the whole essence of the question, and I venture to say as I have said, on another occasion elsewhere, when Captain Colomb has been discussing this question, it is my opinion, as having had some experience in Colonial legislation and government, that if England does become involved in a great war, a war in which her command of the ocean is materially affected, it will have one of two results, either it will blend England and her Colonies into an Empire such as the world has never yet seen, or it will entirely separate those Colonies from the mother-country. I believe it can have but one of those two alternative effects. What is the end every man would wish to bring about? Is it not the one that Captain Colomb is driving at in his paper—and it is not the first occasion he has been driving at it—that is, the uniting together in one whole the enormous resources of the entire English Empire?

There are one or two points I should wish to allude to, to which Captain Colomb has referred. The one is the supply of horses. I believe that question of the supply of horses from the Colonies to England for English purposes must practically be laid aside. The cost of obtaining them is too great: you cannot get a horse from Australia under some 50*l.*, and the tonnage required to bring them

over is so great that this point would be of no practical importance. But when you come to the supply of horses to India, why Australia has supplied India with horses for years past, and it is proposed to supply India with any number of horses that India may want. Then again you can raise and supply any number of horses at the Cape Colony. Although you hear a great deal about the horse sickness and the tsetse fly, those are chiefly confined to localities, and some of the finest horses any one can wish to ride are to be found in the Cape Colonies, and I believe those gentlemen who have been there will bear me out in saying that there are no hardier or more serviceable horses to be found in any part of the world than are to be found in the Cape Colony. There is another question, when you want horses you sometimes want men to ride them. Now I believe you might raise 5,000 of the finest cavalry the world has ever seen in the Australian Colonies, men who can ride anything and go anywhere, and if you get the horse and get the man you may obtain from the Australian Colonies very useful assistance in time of war. We have been told that Canada can supply men. I do not think Canada is so very great in the supply of horses. But England can obtain, when necessary, men from Canada, and she can obtain to a very large extent the necessary resources for forming in the Australian Colonies a subsidiary navy that would be of effect not only in protecting their own shores but in protecting the commerce of the country for a long distance around, that would be an assistance that could not be despised. The Australian boatmen and sailors are nearly all Englishmen. Some of them are native born, but they are some of the finest seamen in the world, and if you want to see a really good crew of boatmen you should see an Australian whale boat pulling through a heavy surf—that will be enough to assure you that you can find good seamen and boatmen out there. Captain Colomb alluded to the wild horses. The horses that are shot on the Australian runs, as a rule, are not worth anything. I am sure Captain Colomb would not care to ride one in Rotten Row: I am quite confident the greater number of them would not come within the definition of "a charming lady's horse," "such a lovely "mane and tail!" These horses are the refuse of some of the bad horses introduced in the very beginning and could not be counted as part of the supply, nor are they counted in the returns of horses made by the Government officials. As to the supply of coal, I believe naval Officers do not like the supply of coal from the Australian Colonies for war purposes, but the Australian steamers use the coal without any difficulty. The mail steamers burn Australian coal. Australian coal is largely used by steamers in the Chinese and Indian waters, and the only reason why it is not liked for war purposes, as far as I have been able to ascertain, is that it is a smoky coal. I think that is merely a question of the construction of the furnace for burning the coal. The furnaces of the Navy are constructed for particular coals, but there is little difficulty in constructing furnaces which will burn coals that make a great smoke. Then as to the supply of food. I think with Captain Colomb that that is the most important point of the whole, that if the food supply of this country was cut off, and it can be cut off in a way that has never yet been tried—there is no occasion to go to war—countries can prevent the export of food and so prevent England from obtaining it. The question was asked if the Colonies can supply England with food. If you take the present demands of England for food the Colonies could not at the present time supply the whole of it; but if England is prepared to purchase from them everything she wants at a fair price they will supply it. The produce of the Colonies is increasing to a wonderful extent. The produce of Australia alone has increased to an extent that no one, even when I left Australia, ever contemplated. It was always said the inhabitable part of Australia was only a small belt round the coast, but they find that is all a mistake. As agriculturists go into the interior the whole nature of the country alters, and land declared to be unfit for agriculture now grows the most splendid wheat the world has ever seen. At the Paris Exhibition it carried off the prize against the whole world. This is a material fact as affecting the future population of one of the largest portions of the world; the inhabitable parts of Australia are shown not to be a small fringe, but as you go further into the interior, land declared to be utterly unfit for any purposes is found to be admirably adapted for agricultural purposes. I am glad to find Captain Colomb bringing forward a question of this kind, and still more so to see assembled on an occasion of this kind a large number of Officers who have had experience in

every part of the world, who know the importance of the question, who know that there is no more important question for this country to decide than what shall be her relations with her great possessions. If she is to continue as a nation she must continue as the greatest nation. England cannot afford to take a second place, and when she once begins to descend from the position she has occupied, her downward course will be extremely rapid. For my part I have perfect confidence in the future of this nation. I believe the day will come, it may not come so early as some may wish, but it will come, when we shall see perhaps within this City of London the formation or at all events the commencement of an Imperial Federal Council, a Council which will decide all questions which are of common interest to the whole of the British Empire, carefully avoiding all those local details with which the Empire generally has no concern whatever, and I believe that the attainment of that end will be the noblest work that any statesman, whichever side he may sit on, can engage in, and I believe then we may yet find that Anglo-Saxons in all parts of the world will unite together and form, both for offensive and defensive purposes, "the greatest "Empire that the world has yet seen."

Captain P. H. Colomb: There are but two remarks I think I can usefully make on my brother's paper. Speaking of "drifting," we have had an instance quite recently of how the thing is done. The war in Zululand called for a telegraphic cable to the Cape. Now it has been known for a long time that our greatest defect in the telegraphic protection of our food lines, and trade lines, lies not in the Indian Ocean, which is very complete in its telegraphic arrangement, but it lies in the Atlantic, and particularly in the South Atlantic. The interest to England from a defensive point of view of a telegraph line running through Ascension and St. Helena to the Cape is enormous; no person who has studied it can doubt that. People who have not studied it may doubt it, but the longer they study it, the more they will come to my opinion. But now we say there is the fact that it is a shorter distance from Aden to the Cape than from England to the Cape; the consequence is, the cable is laid from Aden to the Cape where it is least valuable, not from England to the Cape through the depôts I have named, where it is most valuable. So that we see, when a question of this kind arises, it is not the Imperial view which is taken, it is the immediate necessity of the case which governs the result. That is a thing we must have, and always will have in England, and this particular case I bring forward chiefly to say that, after all is said and done, is not the other side of the question very consoling? I understand it will only be a few weeks before the cable is laid from Aden to the Cape. Although we lose the chance I have spoken of, we gain the knowledge that if we make anything like respectable preparations beforehand, in the case of a war, the cable I have spoken of could be laid from England through Ascension and St. Helena to the Cape in a very short space of time, so that there is the disease and the antidote beside it.

The other point is a matter of detail; but the lecturer rightly, I think, called upon speakers to supply those details which their own experience would give them, but which were necessarily wanting in the summary which he put before us. I refer to the question of constructing our furnaces so as to burn Colonial coal. In China this question was continually before me in a practical form. I suffered anxieties and trouble from the fact that the boilers of the ship under my command were fitted to burn Welsh coal, and not the more smoky coals of Australia, of Japan, and Labuan. The loss of money, speed, and time, and the anxiety of mind which one suffered from a short supply of coal, which was rendered more short because good Welsh coal could not be obtained, I need not speak of; it will be patent to everyone who has commanded a ship under such conditions. But looking at the map before us, I should say this: We have some 22 or 23 ships always in China. Look at the distance between Australia and China, look at the distance between England and China. Does it not seem something strange that the question of the size of the tubes in your boilers, and the method of constructing them, should force you to carry your coal all that distance from England to China, instead of the very short distance from Australia to China? One felt this very much by seeing, as a gentleman has mentioned, that the whole of the mercantile marine on that station were perfectly competent to burn any coal put before them. It was only our unhappy men-of-war that were struggling with the smoky coal, and wasting large quantities of it, because of the

method on which their boilers were constructed. So strong was that pressure, that we had ultimately to decide on getting larger supplies of Welsh coal direct from England, and rejecting to a very great extent the Australian supply, which was cheaper and better. Yet here, again, some remedies are in course of application. I understand that, by the enlargement of the tubes in the newer boilers, some part at least of this difficulty is passing away.

Colonel Strange: In answer to previous questions, I should like just to point out another enormous field of food supply, namely, the Valley of the Saskatchewan, in Canada. I cannot but think, in ten years' time, if Great Britain chose to create a demand in that quarter for grain, the supply would be something marvellous. Then as to military Colonists, you must remember you have given the Crown lands to the Colonial Governments; they are not yours to give away to your soldiers, though no doubt some arrangement might be made. I have had some experience in the question as to whether soldiers make good Colonists. If you take a 21 years old soldier, and give him a grant of so many acres, it may be bush, swamp, neither he or anyone else knows exactly where, without capital, experience, or much physical energy, can you expect him suddenly to blossom into a hardy farmer? I have seen and heard of a good many instances of their blossoming into little else but helpless broken-down drunkards, ready to sell log-hut and land for a very small trifle. The proper system of Colonization is not the system of Colonization by *drift*, it is the old system of the Elizabethan era, when men called their Colonies *plantations*, because they were something that was intended to take root and grow. If you have military Colonization you should have military organization with it. Pick out soldiers and Officers who are willing and fitted for that sort of work. Put the men in the first instance as labourers on military farms, under special Officers, until they have learnt to manage a farm of their own; discipline being still maintained by Officers as civil magistrates. In that way you may establish military Colonies in places not already thickly populated. Such well-ordered frontier Colonies would develop a country, and be a source of military strength to the Empire.

The Chairman: I believe it is the general desire that the discussion should terminate now, in order that it may be resumed after Captain Colomb has read his second paper. I am quite sure we shall all feel that the lecturer has taken a wise course in dividing his most important subject into two parts. It is too vast to be treated exhaustively in a single paper. When the second paper has been read, the whole subject will be before us, and can be discussed more completely than is possible to-day. I can only say, as a Member of Parliament, I feel profoundly impressed with the importance of the subject, and with the difficulty of moving forward in the matter as vigorously and promptly as one would desire. But I must reserve myself for the next occasion, in order to explain fully the view I take of this question. I have now to express on your behalf your most grateful thanks to the lecturer for the able paper he has given us.

Captain J. C. R. Colomb: I should just like to say one or two words in reply, Mr. Strangways seemed to imagine that I proposed to bring horses from Australia here. That was not my intention. I meant simply that the Colonial horse resources were great; that there is no doubt that your pressure for military resources will come in that district of the world where three continents join, and that if you bring some of your force there from India, you bring their horses, and you can fill their vacancies in India from Australia.

The meeting was then adjourned to Friday, 4th April.

2nd Day's Discussion.

Captain Long, R.N.: I am not in any way competent to criticise the valuable papers that Captain Colomb has so ably placed before us; I only wish to mention a fact which illustrates what he has said. In 1876 I happened to be in the North Pacific, at the time when there was danger of war breaking out with Russia. The Colonists

at Vancouver's were then very anxious, and began to think about what they would do to protect themselves if war broke out. An artillery Officer, who happened to be there, drew up plans, by which three or four batteries, mounted with obsolete guns, might have been got ready to protect the place against the Russians. That was the only means available at the time for the defence of the only place in that part of the world to which the Navy had to look for its stores. As there was a squadron of seven Russian men-of-war at San Francisco at the time, who might with the greatest ease, had war been declared, have descended on this Colony, and possessed themselves of the whole of our naval resources, I think that shows that we do sometimes drift about in rather an inconsistent manner.

Colonel STRANGE, R.A.: With reference to what Captain Long has said, I may as well tell you that a detailed account of that artillery Officer's report (Lieutenant-Colonel Trevor) will be found, together with very interesting and important information regarding the Militia of Canada, in the Militia Report by General Sir Selby Smyth, from which you will see that, in spite of the evident necessity just pointed out, beyond making and arming those batteries, in which the Navy lent their able assistance, and attempting to raise a volunteer battery of artillery, nothing has been done. The rate of wages is so high, that it was found impracticable to get men willing to be professionally instructed as artillerymen. Therefore, that question remains as it was left, and the Colony can scarcely be blamed, for we must all see that the protection of the naval station at Vancouver's is an Imperial concern.

With reference to the general remarks of the lecturer as regards Canada (with the military requirements of which I ought to be somewhat familiar, having been there for seven years), I can only say that they are quite correct. One exception would perhaps mislead you, though it may not mislead the lecturer. I may as well point out that when he speaks of the Canadian Army as 600,000, and asks whether there are arms or ammunition for that army, he knows, but everybody here may not remember, that the 600,000 is only an army on paper; it is the Reserve Militia, which is merely enrolled, not mustered, not trained, not armed, and without efficient Officers. I think the lecturer pointed out how much Canada is in advance of Great Britain, in acknowledging the fact that every free-born Englishman, whether on this side of the Atlantic or the other, owes a debt of personal duty in the defence of his country. It may be outside the mark now, but I think the very valuable, and, to me, very saddening remarks of the able lecturer can only point to the conclusion that some such necessity has already arisen at home, and that we at home should set our Colonies an example by acknowledging this principle. I would answer the question as to whether there are arms for these 600,000 Reserve Militia by saying there are not. There are at present only 21,000 rifles in store, and 40,000 in the hands of the Militia, and I believe the small-arm ammunition in the country is only 150 rounds per rifle, which would be barely sufficient for one or two general actions of the Active Militia of Canada. Relying upon a supply of ammunition from a base 4,000 miles away, in case of emergency, does not require me to characterize it by its proper name. The General Officer Commanding in Canada has drawn attention to this and to all other points, in a very forcible and able report. He has made recommendations, and it is not his fault that they are not carried out. I allude to General Sir Selby Smyth. I think it is absolutely necessary, in spite of the danger of too much localization on the part of the Colonies, to develop, especially in Canada, some species of manufacture of ammunition and war material to meet emergencies. That, I am happy to say, has already to a small extent been begun, by the conversion of the old smooth-bore guns, of which there are a great many in the Colony, on Sir William Palliser's principle. As to the permanent nucleus of regular Colonial troops, of which the lecturer has been speaking, it would be very advisable that the depôts of these nuclei should always be in Canada, otherwise, within a short time you will have those battalions becoming like the 100th Canadian Regiment at present, a very splendid regiment, I have no doubt, but Canadian only in name, without a Canadian in it; and when bodies of soldiers have to bear a name with which their hearts do not beat in sympathy, it is a mistaken military principle. Therefore, with these regiments, care should be taken that they remain Canadian, and that the depôts of the regiments should be kept in Canada, where they would be very necessary as nuclei in times of civil disturbance, or foreign or Fenian raids.

Captain BRIDGE, R.N.: I should like to ask Colonel Strange if, in saying that the naval defence of Vancouver's Island was an Imperial question, he meant us to understand that the Colony, as a Colony, was to take no part in its own naval defence. If that was Colonel Strange's meaning, I am afraid I am one of the small minority who do not agree with him. Vicious and imperfect as our system of Colonial defence has been shown to be in the two very able papers that have been read by Captain Colomb, I think no part of it has been more vicious and more imperfect than that which has left anything like an organization of the enormous naval resources of the Colonies entirely out of sight. If there be one occupation throughout almost every one of our Colonies which employs the services of a larger number of the inhabitants than any other, I believe it to be that which is concerned with the sea and sea affairs. If we take the number of seafaring people and fishermen in the great Dominion of Canada; if we take the numbers in the Australian Colonies, and in the Colony of Newfoundland, I think we shall find that those numbers far exceed those of any other profession, trade, or employment in the whole of the Colonies, either singly or grouped together; and yet, as far as we know, not a single attempt, since we first became the possessors of anything approaching a Colonial Empire, has been made to turn them to any account. It can hardly be said the very small numbers of men who have been raised in Victoria, 119 I think, and the 286 volunteers in New South Wales, are worthy in any way of the name of an organized naval force, or even the nucleus of one. The fact is the more singular, because during the whole of our long Colonial history there have been persistent attempts to organize and form *military* forces for their defence. Notwithstanding the fact that in nine Colonies out of ten, possibly in all, a mere land force, necessary though it may have been for their protection, has been unquestionably second in importance to powers of naval defence. The Dominion of Canada having a frontier, on the other side of which there is a powerful foreign nation, is of course to a certain degree an exception; but at the same time, considering the enormous maritime interests of the Lower Provinces and of a great part of Canada herself, I think even there it can be scarcely said that some means to protect her shores from hostile attack by sea are very much inferior in necessity to the means she has of protecting herself against the single enemy that can come against her by land. We all know the distinguished services of Colonial military forces which have been raised from time to time, the old Canadian Rifles, the Cape Mounted Rifles, and others, are very familiar to us; but never in the whole history of our Colonial policy has there been a single occasion upon which any attempt has been made to supplement by any suitable means the powerful naval force belonging to the Imperial Crown, by any effort on the part of the Colonies themselves, with the single exception of the purchase of an ironclad by the Colony of Victoria; an ironclad for which they seem to have got no men, and the condition of whose boilers and engines is probably very inferior at the present moment to what it was when she went out there nearly ten years ago. It therefore seems that even when an Officer so eminent for his knowledge of the subject as Captain Colomb devotes his attention to the naval and military defence of the Colonies, he is obliged, when he comes to give us an account of what has been done with a view of defending them against maritime attack, either to leave it out altogether, or to say that what there is amounts to nothing at all.

NOTE.—The length to which the discussion promised to be carried, and to which I had already extended the remarks I ventured to make, induced me to desist from saying any more at the time. But what I particularly wished to do, was to emphasize the remarkable fact—so apparent from Mr. Brassey's and Captain J. Colomb's lectures—that, whereas our Colonial Empire is the direct product of our maritime strength, and depends entirely on the maintenance of the latter at its proper level, we have persistently neglected to make, not adequate, but *any* provision for its proper maritime defence. Though land forces are not in the first place necessary for the defence of any Colony but one, if in the *first place* even for that, and though men to fill their ranks can only be obtained by withdrawing them from occupations from which they can be very ill-spared, we have concentrated all our efforts on organizing such forces, and have left out of sight not only the naval necessities of our Empire and its dependencies, but also the fact that a large body of seafaring folk are available for employment, and—as their proper avocation would be then inter-

rupted—could be usefully employed in a naval war, the only one likely to be waged against them by a civilised power.

Mr. LABILLIERE: I would ask permission to speak at the present stage of the discussion, because I think a misconception might get abroad from what has fallen from the gentleman who has just sat down. He has told us that what has been done for the defence of the Colony of Victoria, to which I have the honour to belong, practically amounts to nothing. Now I think that his opinion on the subject will strangely contrast with the report which has been given by no less an authority than Sir William Jervois, who, when he inspected the defences of the Australian Colonies, reported that those defences were in a very advanced state of proficiency; and having pointed out in what respects it would be necessary to improve those defences, all his suggestions have been accepted by the Colonial Governments to whom they were given. People in discussing the question of Colonial defence are very liable to fall into very considerable error by not considering the different classes of Colonies within the Empire. We have infant Colonies which at the present moment cannot defend themselves, and which must rely upon Imperial resources for protection. Many of those Colonies are growing rapidly out of that stage of infancy, and instead of looking to the mother-country for defence, they will ultimately become most important sources of strength to this Empire if we only have the wisdom to consolidate the Empire, and to organize its defences in the manner in which Captain Colomb has indicated. The Australian Colonies are rapidly growing; they have in fact grown out of that stage of infancy when they need look to the mother-country for assistance to defend their harbours and coasts. They have established, both in New South Wales and Victoria, systems of defence. Captain Colomb has spoken about ships for the protection of the harbours of Sydney and Port Philip; but I think we must regard such ships not as properly forming part of the general navy; they are solely intended for the defence of the particular ports in which they are stationed; and however numerous eventually the other vessels may be which the Australian Colonies will be able to contribute to the general defence of the Empire, it will be absolutely essential for the protection of Melbourne and Sydney that ships like the "Cerberus" should be kept in these harbours. I believe the opinion of the most competent military and naval authorities is that, considering the nature of Port Philip and Port Jackson, the best means of defence will be ironclads of the description of the "Cerberus" to supplement the batteries which are placed at the entrance to the harbour; and ironclads of a nature well suited for the protection of ports may not be adapted for external operations. I take it that the recommendation of Sir William Jervois with regard to South Australia is that that Colony also should provide itself one of those vessels for the protection of Adelaide. Now Adelaide is not circumstanced as favourably for the purposes of defence as Melbourne or Sydney, the roadstead being an open one, and the port only adapted for vessels of limited tonnage. I think the whole experience of our past Colonial history is this, a willingness on the part of the Colonies to do everything they can for their own defence and protection. You may hear at the present time people who know nothing about the subject talking of the burden of the Colonies to the mother-country, and especially about British troops being sent out to South Africa. But we must remember that Natal, which is 1,000 miles from Cape Town, is but one of those infant Colonies of which I have spoken, a Colony with a white population of only something like 20,000; and how can you expect a Colony like that to be able at present to wage a very important and heavy war? Is it, then, the policy of England o abandon such a Colony? Is it not the policy of the mother-country to assist a Colony of that kind in its infancy in the hope that what has happened with regard to the other Colonies will happen with regard to the one in question, that the Colonies of South Africa will grow in importance like the Australian Colonies, that they will in the course of a few years, perhaps in the lifetime of men living, have large European populations like those of Australia, which will become a great source of strength to this Empire if organized in their defences and common concerns as integral parts of it? That is a most short-sighted policy which would say "Do not extend your "Colonial Empire; do not defend those portions of it which are at the present moment "incapable of defending themselves." Be assured of this, that everything you do at the present time with regard to helping infant Colonies will be remembered in the

future. It will be remembered how British soldiers gallantly laid down their lives in South Africa; and the time may come when those Colonies will be glad and will be able to add powerfully to the defence of this country, to the defence of our common Empire in some future emergency. We remember that famous expression that "blood is thicker than water." I believe, therefore, that it is most important for us in times of peace to consolidate our Empire, to organize its defences, to develop those marvellous resources which we possess within it for mutual strength, safety, and protection. I believe that the time may come when by organizing these defences we shall have an Empire so great and so powerful, that without in any way interfering with any other nation we shall be able to hold our own. I believe we have only to admit the Colonies to a participation in the general management of the affairs of the Empire to induce them to do anything that is needed from them in the way of our common defence. Why, we have had an experience within the last few months what Canada was prepared to do if we had been drawn into a dreadful war; we have also heard that Australia was prepared to take her part; and although God forbid that we should have any great war, I believe nothing would tend more (and I speak as one of Colonial birth and bringing up) to consolidate our Empire than if we were obliged to stand shoulder to shoulder in its defence against a foreign foe. The confederation of our Empire is a question in which I have taken the greatest possible interest. When, five years ago, I had the honour of reading a paper at the Royal Colonial Institute, upon the ultimate federation of our Empire, I was told I was a theorist, and that I was talking about a question which might be of practical importance 50 years hence. But I was satisfied for the moment to remain under such imputations. I knew that as soon as the question of defence had seriously to be considered in the view of any foreign eventualities, the question of Imperial federation would come forward as a practical one; and this and other discussions have shown how extremely practical the question of Imperial federation is daily becoming.

Mr. DONALD CURRIE, C.M.G.: It is hardly possible to over-estimate the value of the paper which has been read by Captain Colomb, or indeed to value too highly the services which he has rendered to this country for many years past. Captain Colomb has repeatedly called public attention to the subject of the right organization of the national forces, and the necessity for suitable means of administration. In no country in the world are there better opportunities for full information, and yet very little is understood as to foreign politics. We are also a very practical nation, and yet no other nation with such means has so limited a power or faculty of employing thoroughly the resources at its disposal. So far as I know, not a single theory which has been advanced here for years past has had practical application. Take the Pacific. Captain Bridge has forcibly drawn attention to Esquimalt and Vancouver's Island. I happened to cut out of a London paper the following extract:—"A correspondent writes to us, that the movements of a Russian officer who has arrived at "Esquimalt have been watched with some interest, for it will be remembered that "when a Russian squadron was expected to appear in the Pacific, at a time when our "relations with that country were rather strained, the unprotected state of Esquimalt "was the cause of some anxiety. Steps are now being taken to afford better protection "of so important a depôt, and it is conjectured that the Russian Government is "desirous of being informed and kept informed of the condition of this British possession." Now Captain Colomb, some two years ago, delivered an address, in which he referred to the danger to this country from the preparations of Russia in the North Pacific, and looking to the value of Esquimalt Harbour, and of Vancouver's Island as a coaling station, what would be our position if our squadrons happened to be out of the way, or if those obsolete guns, which have been referred to, did not, in case of attack, go off? Captain Bridge referred to the absence of particular reference to the naval resources of the Colonies. But a year ago, Mr. Brassey delivered a lecture on this subject, and spoke of the establishment of a Colonial Naval Reserve. On that occasion I advocated the appointment of a Royal Commission to inquire into the matter referred to by Captain Bridge; but the suggestions then approved of, have had no practical effect, just as Captain Colomb's paper will, in all likelihood, have none, for some time to come. Need one refer to other ways in which this country does not drive a practical authority into the carrying

out of measures for the national good? I do not know how you are to do it, but Captain Colomb does his part, I should wish to do mine, and every man should try to do his, to force in upon the public mind the necessity for complete and timeous preparation and efficiency. I will give you two or three illustrations. When the Crimean War broke out the legs of iron bedsteads for the sick and wounded found their way in one ship, while the bottoms and ends of the beds reached their destination in other ships. It was called a departmental error. I remember also in the Ashantee War, when Sir Garnet Wolseley required a telegraphic land line, which he judged would be of the utmost importance in the proposed military operations, this was sent in a slow vessel to arrive just in time to be too late. The Officer in charge, however, trusted to himself and took with him a few miles of the wire, which he managed to lay in good time to the Prah to be of some service. We are told by Captain Colomb that organization of the Colonies in their food supplies, horses, men, and resources generally, is what we are to look to. This is quite true. You have the raw material there; but you must first of all see that the public mind is prepared, and that departments are ready, to make the proper use of these resources. You must come to the decision in time how you are best to employ these forces. To know what is required, and to do what should be done, are different things. I had the honour of reading a paper here two years ago on Maritime Warfare, and none of the things which I then suggested have been adopted, although the members of this Institution thoroughly agreed with me. This is not very encouraging to men like Captain Colomb. I suggested, for example, the importance of having suitable naval coaling stations, and of looking well to their defences. Well, nothing has been done in that respect. When the Cape War began, you know very well how quickly arrangements were made for the despatch of the troops, but is it creditable the speed with which the transports were coaled at St. Vincent? And was it necessary to engage vessels requiring to coal on the way to Natal? In such an emergency as the Zulu War why limit the number of transports engaged if they required coal, so hindering by delay the arrival of the reinforcements in South Africa? I venture to state that the Mercantile Marine of this country could have supplied a sufficient number of transports fit to make the voyage without the delay complained of, and which delay may entail very serious consequences to our army in Zululand. The Government may not have known it, but some of the steamers chartered burn 100 tons of coal per day, and this at the Government expense. The delay at St. Vincent will reduce the time within which these vessels will arrive to about the speed of a collier all the way through, while the expense in charter money and coal will be far in excess of the cost of really suitable vessels. If our arrangements even in coaling in a small war are so peculiar, what may we expect in a great struggle and with a Naval Power?

I spoke also of graving docks in that paper. Now it is a singular fact that in the present African War, out of the three ships which H.M. Government had on the Cape Coast at the time of the commencement of hostilities, one had to be sent to Mauritius and the other two ran ashore. Accidents will occur, and I charge no one with blame. My point is this, we have no graving dock at Simon's Bay, or on that coast, where these men-of-war could be repaired; and consequently they had to be kept afloat (for they were the only ships on the station) with the hope of getting repaired in England some day or other. In the meantime they ran great risk of being wormed in their timbers. A third recommendation, which you all approved, was the establishment of telegraphic strategical lines, and especially of a line to the Cape. And I pointed out then the probability that we would have an African War. But no steps were taken to establish telegraphic communication. I think I may safely say that if it had not been for the disaster at Isandula, you would not have had the decision to lay the Cape telegraph. Notwithstanding the arguments of such men as Sir William King Hall, Sir Garnet Wolseley, and others who spoke here in favour of an alternative line of telegraphic communication to India by the Cape, not a single thing would have been done if it had not been for a sudden national disaster which has quickened the perceptions of the public, and nerved those who are charged with the conduct of Government to a decision in this important matter. Are we to wait always for disasters to teach us what this country should do? I would merely mention one other practical thing, to show that it is only when something specially

striking occurs that anything is done, instead of preparing in advance, honestly telling the country: "That will cost so much, do it. It is not our blame if it is "not done." When the Cyprus Expedition was sent, and six millions sterling had been voted, and a large part of it was spent, we were led to believe that in the event of war, 30,000 troops could be despatched, and another 30,000 immediately afterwards, with every material appliance. But when our arrangements were tested, they were so defective that the 10,000 soldiers who reached our new Mediterranean possession, a distance of only about three days' steaming from Malta, our head-quarters in the Mediterranean, they were put ashore without huts or suitable arrangements being made for their comfort or health. The result was sickness and death, almost a disaster; ending in the order for the troops to move away from Cyprus as fast as they could; only half a battalion being kept on the island. If such things occur when we are taking possession of an island, where no one opposes us, what is to be the system under which we are to disembark forces in the face of an enemy? Some time ago the Admiralty, under Mr. Barnaby's excellent advice, urged that a plan should be matured for the employment only of the merchant shipping of Great Britain in case of war, and that gentleman demonstrated the principles on which troops could be safely conveyed, and merchant vessels fitted for war service. Upon this subject, there have been lectures here and elsewhere; but nothing has come out of it. The Admiralty got offers of hundreds of ships, and received hundreds of drawings. These drawings are carefully laid by in their boxes, and when the emergency arrives, this country will enter on the consideration of the plans referred to. No arrangements such as Mr. Barnaby recommended have been made for testing the efficiency of merchant ships in carrying guns, or to act as cruisers in the event of war. We have left it to the Russians to carry out these ideas, for they on their part have the "Cimbrias," "Asias," "Europes," and other vessels prepared and fitted. They were ready with swift cruisers if we had gone to war; and we should take a lesson from the Russians in this matter; it is quite possible we may yet be in conflict with that Power. I do not wish to speak in a tone of reproach against authority, but people should be wakened up to a full apprehension of what is required. Certainly we are talking a great deal, the newspapers are writing much, but little or nothing is being done in the way of preparation. Let us all do what we can to help forward the due organization and administration of Imperial and Colonial strength and power, so that this country may be ready for any emergency. Otherwise we may meet with grievous disasters. We have had the Eastern Question with its complications and dangers, the Affghan Question, the African Question; one of these days, I believe, we will have a Colonial Question. And that question is touched by the *data* and thoughts of Captain Colomb's paper. We must all hope that any question between the Colonies and this country, as well as with regard to our resources, and the use of them, will not come up when we are at war. It will be well if the people of this country, and those who lead public opinion, can realize what should be the relation between Great Britain and her Colonies. Time will develop this problem, and I hope unite us more and more. A common sympathy and loyalty, a thorough union in feeling and of interest will be developed, and in some joint and cohesive, or even Federal linking the British Empire will yet exhibit the solid strength of an organized force and power such as the world has not yet seen.

Mr. Barnaby: Matters move very slowly in England in official circles, and there is a great deal of truth in what Mr. Donald Currie has just said; but he has forgotten, I think, that the Admiralty have actually done one definite thing; they have actually fitted up the much despised merchant ship as a fighting ship of war. The "Hecla" is now going with the fleets to different parts of the world, and I believe she is getting into favour with naval men, and they are beginning to feel that there is in the merchant shipping of England an enormous element of strength. I came here this afternoon from the Institution of Naval Architects, where we have been talking about the "Hecla," in order to show my sympathy with the gentleman who has done us the honour to read a paper to us. I have followed for some years past the work he has been doing with the greatest possible admiration and sympathy, and I should like to say to this influential meeting that you are going to do one of two things; you are either going to publish to all the world statements about which

we all ought to blush, or else you are going to use your great influence in getting something practical done on the questions that have been brought before you. You cannot have these papers read before you without taking that great responsibility. It is a very serious matter that you should lay before the world such statements as Captain Colomb has put before us to-day. They cannot be challenged, I believe. While it sometimes happens that you have a distinguished man like Sir William Jervois going out to a particular Colony and making a report, I believe if he would have two hours' conversation with Captain Colomb, he would find that he had only looked at a very small part of the question; that as a matter of fact he had omitted all those vast elements of strength which lie at our hands, if we would only take the pains to organize them properly.

Mr. STRANGWAYS: I should say, in reply to the remarks of the last speaker, that I do not think the publication of Captain Colomb's paper can do any harm to this country in any shape or way, for the simple reason that all the material facts which Captain Colomb has collected in such an admirable manner are open to every foreign nation who chooses to invest a few shillings in the purchase of Blue Books, published by the Parliament of this country, and by the various Colonial Governments. When I came to this meeting I was very strongly prepossessed in favour of the views advocated by Captain Colomb; but after hearing the remarks of Mr. Donald Currie, I am certainly disposed to think that the best thing the Colonists could do would be to cut the whole thing altogether. Perhaps, however, we may get over that difficulty by following such advice in the future. I listened very attentively this afternoon to hear if there were any practical suggestions made by one who announced himself to this meeting as essentially a practical man, and having paid all the attention I possibly could, I was unable to see that there was one single practical suggestion of any kind from that quarter. There is no doubt whatever that Governments make mistakes; they have done so from time immemorial; but merchants do the same; merchant ships get ashore in the same way as men-of-war do. Allusion was made to the state of affairs in South Africa. I merely mention it because great stress has been laid upon the question of Confederation. I have paid considerable attention to the South African question, and I think that many of the difficulties now taking place in South Africa are owing to the mistakes made some two years ago. It is not a question that has arisen in the last year or two, but it is one that has been cropping up for several years past. As to the question of assistance given to the English Government by the Colonies in time of war, I am strongly in favour of that proposal, but it will resolve itself unquestionably into the old practical question of £ *s.* *d.* Will it pay? that is the main question. You must be prepared whenever it crops up to remember this; that if the Colonists are called upon to contribute to any general system of Imperial defence, they will require their full share of the patronage. It has been pointed out that there is a Canadian regiment probably without a Canadian in it. Now, if you have these Colonial regiments, you must give a fair share of the patronage to the Colonists; thus if any particular Colony is called upon to contribute a quota, say a dozen Officers and 500 men, although the Colonists might not require that the Officers of that particular force which they were called upon to maintain should be selected from people belonging to that particular Colony, they would require that they should have an equivalent share of the patronage in the whole force. I do not think there can be any doubt that the cool manner in which the Colonists have been in the habit of treating all questions of this kind has been because they know the view.—"You find the money, and we will find the brains." They are not prepared to do that. I do not say that the Colonists in such matters are as highly educated—in purely scientific matters—as men who are devoting the whole of their lives to these questions; but the Colonists have a certain amount of knowledge of the ordinary transactions of everyday life; and such men can, I submit, with a comparatively small amount of training, be converted into good, useful soldiers. I would suggest, also, whether the Army and Navy are not getting a great deal too scientific. At the time of the first accident on board the "Thunderer," when the boilers burst, it was stated in the evidence, that there were no less than 700 steam taps on board, which had to be properly manipulated by the various officers to keep the machinery of that ship in working order. Captain Colomb concluded by saying

he was not sure whether the Naval supremacy of England did not cease at Trafalgar, and was not buried in Westminster Abbey. There are as good fish in the sea as ever came out of it. It has been the experience of this country, and there is every prospect that it will continue, that when the hour comes, the man comes also. As for the Navy of England sinking into insignificance, why from the days of Trafalgar to the present time the Navy of England has been, and it now is, the water police of the world, and so far from it ever sinking into insignificance, I say that at the present time England by herself commands the ocean, and while she has the skill and ability, and while you have the same pluck to man the ships that you had in the time of the great war, and remember that you have not only the men who are in England to fall back upon, but you have millions of men of the same nation, the same breed as yourselves, to assist in manning those ships. Whilst that continues, you need never be afraid that the Naval supremacy of England will cease.

Captain R. A. E. Scott, R.N.: One cannot but agree with the concluding remarks of the last speaker, though they seem at variance with his former assertion that we are too scientific. I think what is first required is precisely what Captain Colomb has indicated, viz., organization. We want to be prepared for war; how, then, are we to proceed? This is a great maritime country, the Colonies are maritime also, having the same aspirations and the same feelings as the mother-country, which already has a magnificent volunteer land force of which she is justly proud; 200,000 men have come forward ready to march at the country's call, and to defend her shores at every point. It is a glorious movement, unparalleled in the history of the world. We want a similar arrangement for the sea, viz, "an ocean volunteer force;" and until this is organized, so that merchant vessels are prepared to defend themselves, we cannot secure the great ocean lines of this country's traffic. We have at present a Naval Reserve; but its men are scattered in all parts of the world. This Reserve has been trained to arms at the country's expense, but directly the men have been trained, you have to let them go to distant seas, and being there without any further instruction, they daily forget more and more of what they have learnt. A *trained* Reserve man, when he goes on board his merchant ship, ought to have the means, not only of keeping up his own knowledge, but also of imparting instruction to the rest of the crew, so that everyone on board could assist in the defence of the vessel. You may say that an armament would spoil merchant vessels for trading purposes. Not at all. You have only to put in a couple or four light 12-pounders to give them the power of penetrating any unarmoured war vessel afloat; and I believe it fell rather like a shell when, more than two years since, it was pointed out to the Admiralty that the whole of our unarmoured fleet could be pierced through their boilers and magazines by any merchant vessel armed with a single 12-pounder. The merchant vessel possesses another weapon not to be disregarded, viz., the "stem," which is, I believe, the most important weapon in naval warfare. And who can handle vessels or use this weapon better than the splendid sailors who command our mail steamers? It seems to me that we have started on an entirely wrong policy in the armament of the "Hecla," for I think we do not want a vessel to be *taken out* of the merchant service and converted into a man-of-war; but we want to have the fine mercantile fleet we now possess, armed, and kept efficient so as to be a source of strength to the Navy on the outbreak of war. This can be easily effected by putting two or four light 12-pounder guns on board, keeping them ready for use. I venture to ask how are you in time of war to send merchant vessels to Portsmouth and Plymouth, to put 64-pounders on board as is now, I believe, arranged. The vessels would have to be strengthened to carry 64-pounders, and the magazines altered or built to take the necessary ammunition; and these alterations are intended to be made at the commencement of war, the very time when there would be already a heavy strain on our resources to fit out our war fleet quickly. All our merchant captains should, I think, be in the Naval Reserve (and nearly all the best are so now) but if merchant crews are to be changed for naval crews, on arming merchant vessels, you would remove the very men who know the qualities of these ships to put in men who would know nothing about them; and all these changes would have to be made in time of war! There is another reason against such a course. You would want your most powerful steamers in time of war to keep up your food supplies. The with-

drawal of from 100 to 400 of such vessels would cripple your own resources, and effect just what an enemy would attempt to do; in fact you would save your enemy the trouble of destroying your commerce, by actually doing it yourself. Russia has given us a very valuable lesson as to utilising small resources, by what she has done in arming merchant vessels; but for us, with our vast resources needing only proper organization, to deliberately follow in her wake would be a grave error. Captain Colomb has pointed out that the Colonial ships are mostly small, but it is small vessels that are valuable for torpedo warfare, and hence I should like to see all our own small unarmoured vessels rather than our larger war ships thus utilised. Fast and powerful torpedo boats, with a gun or two, will, I think, play a prominent part in future warfare, and the torpedo is happily the very weapon that is of such importance to us and to our Colonies for coast and harbour defence. I do not wish to criticise the "Cerberus," having had something to do with arming her; but it would have been far better if, instead of the "Cerberus" monitor, the Colony had purchased a few gunboats; and here I come to what has been done by one of our great firms (the Elswick), which has led the way both in mounting heavy guns on gunboats, and in building the vessels. Consider the value of two or three of such gunboats mounting 38-ton guns, and carrying a few torpedoes. What more simple, too, than to have the Home and Colonial coast populations enrolled so as to form part of a great ocean maritime corps capable of manning all the small coasting vessels of Great Britain and her Dependencies. What enemies could then get on our shores safely? The boats employed to land troops would all be run down or knocked to pieces, and their ships must inevitably retire utterly defeated by such a formidable maritime organization as that now suggested.

Captain P. H. Colomb, R.N.: The question appears to my mind immensely wide and immensely deep, and it is to the depth of it I would just address myself for one minute. We have heard from both sides of the theatre denunciations of the defective administrative power of the Government in different forms. What is the cause; what is at the bottom of the whole of these defects as regards the Colonies and the administration of the general defence of the Empire? It is want of administrative power at head-quarters; there is no question about that, and why is that so? It is because the people of England, the Parliament especially, for many years past have been perpetually driving at taking away from the administrative departments the number of heads that are working. Most of the blame, if there is blame for this condition of affairs, is aimed at the Naval Service, and at its administrative head. I would ask the members to go up to the library and look at the Navy List 40 or 50 years ago and see the numbers of men, the position of the men managing the Navy in those days, and then to take the Navy List of to-day and look at it. There are about half the number of heads working that were working there 40 years ago, and, upon the whole, their position is lower. By the growth of your Colonies, and by the condition of things which has been shown to you, you see that the importance of the Navy of England, whatever it was in old times relatively to the other arms of the country, has now multiplied fifty-fold. It is impossible to exaggerate the immense importance of Naval organization, and the maintenance of the Naval Empire of this country; and so vast a question can be dealt with only by having sufficient power at head-quarters, and sufficient time for the heads at head-quarters to do the work that has to be done. When we blame them, we must not blame the individuals, we must blame the system. The result is that any great question of this kind cannot be debated at the Admiralty at the present moment, simply because there is no administrator there who has the time. He is entirely occupied with the petty details of the day; and until the English public rise to the knowledge that, by cutting short the administrative brain power, they are doing the Navy a great injury, so long shall we have the condition of things which has been represented to us to-day.

General Schomberg, C.B: The one sentence in the most able lecture that seems to re-echo in my ears is this: that though the savage with whom we are fighting now does not know that the absence of a few heaps of coal might prevent our armaments reaching him, yet, in the event of war with a European Power, such men as Moltke or Todleben will not fail to know this fact. In very many of the Intelligence Departments of Europe, there is no doubt a plan to attack us already prepared, and no

visionary plan, but one carefully thought out by the best heads in Europe—probably through our Colonies. How are we to defend them? By decentralization. Now we have an Empire in the East, a Dominion in the West, a Continent in the South; we attempt to arm those from Woolwich: our troops are all over the world; we attempt to clothe them from Pimlico. This is the old fault of our administration; if we do not decentralize we shall never be organized. If a war break out, the Commanding Officer, be he naval or military, in each of these Colonies should know precisely what he has to do for defence, when the telegram arrives, "War is declared." It is beyond the power of any human being sitting in the War Office or Admiralty or anywhere else to give details of defence for the Empire and the Colonies by telegram. Everything must be detailed for action in every Colony and outpost, beforehand, just exactly as a ship is prepared for action, or a regiment; and I believe that lies at the bottom of the whole question; you must *decentralize* in order to *organize*.

Captain MAN: In one of the introductory paragraphs of his lecture, Captain Colomb mentioned, as a question of raw material, *men*. Now about one race of men that are coming into our Colonies, it is very likely that few here will have cared to take much heed. Previous speakers have confined their remarks to our own colour—to white men. I wish to say a few words about the yellow race. Captain Colomb incidentally notices the fact that 30,000 Chinese emigrants are working at the gold-fields of Queensland. I think that those words convey a great deal more than at first sight appears. I believe that 30,000 are but the *avant garde* of an immense body of fighting material, of a war resource therefore, which is going—not only to Australia, but to all the Colonies, which can be got at handily from our own port of Hong Kong. This question of Chinese emigration, as an emigration of possible war material, is a modern one. It is a question, not of contract coolies to Demerara, not of shopkeepers to the Straits, but of the hard-headed, hard-handed labourer who is going from Hong Kong, in steadily increasing numbers, by those great steamers which are now running to San Francisco and to the South.

I know the Chinese well as Colonists, for I have served with them, in their own colonies, in peace and in war. There is, in some quarters, a great prejudice against them, but it is a prejudice not founded on facts. As one who knows them well I feel bound to stand up here, in the presence of gentlemen of great experience in the Colonies, and to beg of them not to follow in the steps of the United States; not to keep out what is a really good hard-working material.

Many speakers have referred to the importance of Vancouver's Island to us. Surely one great means of bringing it into the general system of our Empire will be the Pacific railroad in British territory. Depend upon it, that railroad can only be made by Chinese labour. It is but by encouraging Chinese emigration into Vancouver that we can hope to get that link forged.

As for the Colonies of Australia, I fear that I shall be considered very presumptuous if, in the presence of gentlemen opposite, I attempt to give any advice. They must know their own business much better than I do. But this much I will venture to say: The Chinese emigrant, when he is well governed, and when he feels confidence in the governing power, is not what you will hear many people assert of him; he is not what the American papers represent him to be. He is a hard-working man, and moreover he is a hard-fighting man. I say again, there is raw material steadily going South in that line of steamers to Australia, which, if the Colonists will only accept of it, will surely prove, in the future, a grand source of wealth and power.

Mr. LABILLIERE: The Legislature of Queensland, recently following the wise example of the Colony of Victoria, has placed restrictions upon the entry of Chinese into Australia. We want to be a British people, not an Anglo-Mongolian race.

The CHAIRMAN: This is perhaps the most important subject that I have ever heard discussed in this theatre. I hope this paper will not only be laid before members of the Imperial Government, but will be circulated in the Colonies and so be brought to the notice of the Governments of all our Colonies. We must, however, bear in mind the great difficulties there are in carrying out any measure of this sort, or even of assembling a Royal Commission to consider it. As all of you well know, we have almost given up the control of the internal management of the majority of our Colonies. We can only advise; we cannot spend their money; we have no authority to carry out any measure that we may think necessary either for their

internal defence or the organization of any general defensive system. This can only be done by the mode that Captain Colomb has adopted and has been carrying on so well for so many years, bringing forcible arguments and great influence to bear on public opinion in the Colonies, as well as on public opinion at home. There are, however, some steps the Government can take, and I hope they will take them; of these perhaps the most important is the defence of our coaling stations all over the world. What greater prize can there be for an enemy's ship than to go into an undefended port, find a stock of coal, and either destroy it or take it away? Then there is the laying down electric telegraphs for naval purposes when commercial interests are insufficient. There is one I should like to see established between Halifax and our West Indian Islands, connecting Bermuda with the English West Indian Islands. At present we cannot communicate with the West Indies, except through the United States, and it would be of immense importance to us to have a distinct line in time of war. Then there is the confederation of the Colonies for defensive purposes; we should encourage that wherever we can. Look at the grand example of the Dominion of Canada; this I hope may be followed by Australia, the West Indies, and the Cape. I am quite sure that gentlemen from the Colonies need not suppose that Captain Colomb has had any intention of finding fault with the action or want of action of the Colonies in this matter. What he has found fault with is the want of Imperial organization, and I hope that this may lead to the appointment of a commission to investigate the whole question. For the main defence of our lines of communication, we must trust to the Navy, for which purpose our Navy must be kept up in sufficient strength in all parts of the world; but we should look to the Colonies for the local defence of their own harbours, they should construct forts where required, and should have vessels for the defence of these harbours, such as Captain Scott referred to, which might be manned from the Local Naval Reserve force in the Colonies themselves. We ought to expect the Colonies to defend their own ports by means of submarine mines, earthworks and gunboats. I should be very glad to see an Imperial Commission formed to take into consideration the whole subject, and one idea of Captain Colomb's seems to be an admirable one, the organization of regiments in our large Colonies interchangeable with regiments in England. That is the only permanent military defence I can see possible. Then you would have regiments officered and manned by men from the Colonies. The difficulty is the rate of wages. It is not easy to get a man to serve as a soldier when he can get double or treble the pay in doing other work. But what we want is organization. Now I will ask Captain Colomb to reply to the questions asked, and suggestions offered.

Captain J. C. R. Colomb: I should like to make one correction as to that last observation of the Chairman. The interchangeability of battalions in Canada is proposed by Sir Selby Smyth in his report; it is not my suggestion. The suggestion I alluded to, and was taken to include Canada, was with reference to Australia, and that is an old suggestion of mine in a paper read here ten years ago.

With regard to Mr. Labilliere's remark, there is no better authority than his, as historian of the Colony of Victoria, but I think when he reads Sir William Jervois' reports, he will find that it is rather the reverse of what I understood him to say with regard to harbour defence of Sydney and Victoria.

With regard to Mr. Strangways, I confess I am a little astonished to hear so practical a man as himself thinking that telegraph communications to the Cape, the defence of the coal depôts, and the provision of a graving dock at the Cape, are not practical measures. I, myself, am bound to say this, that after some twelve years' consideration, and having benefited by many conversations with my brother, I think these are all most practical questions. One of the most practical papers with regard to general matters concerning our Naval position that I have read, was the paper which was read here by Mr. Donald Currie, to which he just now referred, and which Mr. Strangways seems to think was unpractical.

There is only one other remark I wish to make. I very much fear that some observations I felt it my duty, from sheer conviction, to make with regard to "the supremacy of the sea," have been rather misunderstood. I have as great faith in the Naval Officer of to-day as in any Naval Officer that history has

produced. When I spoke about "the supremacy of the sea," all I said was that *without inquiry*, and in view of all the changes which have taken place, we could not for certain tell whether we have it or not. I say no more than that with an Admiralty centralised as it is, and in the absence of any Imperial plan, I think it doubtful; the supremacy of the sea is too serious a thing for our Empire for us to permit of any doubt about it; and therefore I press for inquiry. What I dread most, what I think is the danger of our English Empire with its growing local military forces, and all the attractions of local military display, is that Englishmen may be led to think in a wrong direction, that these things may breed a purely military and local idea of security, when our true safety lies in an Imperial and a Naval spirit. Therefore I merely correct what appeared to be a misapprehension, for I suppose there is no man in the world who has a higher opinion of the English Naval Officer of the present day than I have.

The CHAIRMAN: I am sure I may return your very sincere thanks to Captain Colomb for the papers he has read to us.

LECTURE.

Friday, May 9, 1879.

General Sir R. PERCY-DOUGLAS, Bart., in the Chair.

SOUTH AFRICA, AND ITS MILITARY ASPECT.

By Colonel H. C. Gawler, late 73rd Regiment.

For a couple of years past South Africa has been engrossing much of the attention of the British Government and of the country.

With the exception of what might in one sense be called an unofficial war with Kreli, in 1857–58, the country had enjoyed a peace of twenty-four years, when an affray, at a native beer-drinking party, beyond our boundary, lighted the torch of war, in which we speedily became involved, and the flame is still alight though the seat of war has been shifted.

I need not speak of the resources of South Africa—its vast agricultural, mineral, and other wealth—that has been done repeatedly by abler hands. Papers have been written and lectures delivered all over the United Kingdom upon the vast treasure we have there; but, to give an idea of the extent of our South African possessions, I will draw a comparison which will the better familiarize it.

The northernmost point of the Transvaal, or late South African Republic, which we annexed about two years ago, is in latitude about $22\frac{1}{4}°$ S. Our northernmost possession on the west coast, Walwisch Bay, is in nearly the same latitude; Cape Agulhas, the most southerly point of the Cape Colony, is in nearly 35° latitude S.; *i.e.*, an extent of nearly 13° of latitude, or within thirty miles of the distance from Calcutta to the most southerly point of India, Cape Comorin. This latitudinal length has a mean width of about 15° of longitude, while that portion of India, which was just mentioned, has a mean longitudinal width of only 10°.

Although there are large patches of this country westward of the Transvaal not formally annexed, we have practically control of it. There are also, independent of us, the Free State; and, in the north-east corner, a portion belonging to the Portuguese, against which, however, the various native States in India, and the foreign settlements of Goa and Pondicherry, may be reckoned as a set-off. Such is our South African Empire.

It is, however, of little advantage or credit to us, the ownership of this vast and valuable property, unless we can advance civilization and profit by its resources; and, among all the embarrassing questions that ever beset the Governor of any British Colony in a five years' term of service, I know of none likely to compete with the South African native question.

It has been proverbial in the history of our Colonies generally, that the black man disappears by indolence, excess, and disease before the white man. But in South Africa the Kaffir element holds its own: a dash of Arab blood is probably the cause of the tenacity, manliness, shrewdness, and good common sense observable in the Kaffir. These remarks apply especially to the frontier Kaffirs of the Cape Colony, the Zulus, and the Fingoes who are of the Zulu stock.

It is how to manage races like these, who will not collapse before us, that constitutes the native question of South Africa, and on this native question depends "the Military Aspect," for if there were no native question, there would be no "Military Aspect," at least in the sense in which it is to be understood in the title of this lecture.

There are four principal bodies or groups of natives in South Africa whom alone it is necessary to consider as having at any time caused us, or as being likely to cause us henceforth, any trouble or apprehension. They are the Cape frontier Kaffirs (under which term I include several subdivisions), the Fingoes, the Zulus, and the Basutos. The first three are what I may call *coast tribes, i.e.*, who reside principally on the eastern slopes of the great Drakensberg chain of mountains, a country of valleys and ravines, with more or less forest and bush; while the fourth, the Basutos, occupy a large portion of the high open central plateau west of the mountains, almost destitute of wood. The three former fight principally on foot, the last are mounted almost to a man.

I am not thoroughly acquainted with the Basutos, but, referring chiefly to the frontier Kaffirs, Fingoes, and Zulus, I have spoken of their manliness and common sense. As uneducated and un-Christian beings, however, these strong points in their character make them, if neglected, all the more dangerous and troublesome, just as the best land, if neglected, will be the most prolific in weeds. Excepting the Fingoes, whom I will notice hereafter, our dealings with these people have been unfortunate in the extreme.

The South African native question demands the gravest attention, or it will become an open sore; and, so far from that vast territory ever becoming a real benefit or credit to the British Empire, it may continue a periodical drain upon the mother-country, or, failing whose assistance, South Africa must be deluged with blood, and Christianity and civilization at a standstill for many a long year, even if the colonists should be able to hold their own. For, though the Zulus bordering on Natal be conquered, we are in contact along a great portion of our new northern border with perhaps the main body of the Zulu nation, under the son of the famous Moselekatse, who rules more or less over the whole tract between the Limpopo and the Zambesi.

For our own interests, then, I would urge greater attention to the native question; but I feel sure that all here will appreciate the still higher grounds on which I would urge it. Hundreds, I might say, of lecturers have dwelt on the wealth and resources of South Africa, and the diamonds, the gold, the ostrich feathers, and the wool, which, for some years past, have been increasing the revenues of the country, and raising it to a high pitch of prosperity; and the least I think that can be done, in all fairness and honesty, is to apply a good fair percentage of these revenues—a little of the gold, a few of the diamonds—towards the improvement of those races whose patrimony we have invaded. It is a mean spirit that would suggest that we have done enough for them when we have marked off locations for them—in others words offered them a scrap or two of their own country—or that we pay a few of them as headmen for undertaking certain duties with which we could not conveniently dispense.

The British races, whose prosperity and natural expansion oblige them to encroach upon the heritages of less favoured nations, are bound, by the sacred principles they profess, to come as civilizers and not as common plunderers; and, if we force ourselves into the position of managers of neglected estates, it is but bare honesty that a percentage of the revenues, which our superior wealth and knowledge teach us to extract from the country, should be applied to the elevation and improvement of those whom we found in possession. If they are worthy, they will benefit by our management, if they are not worthy, they will die off before us; but it is our business not to estimate their worthiness, but to do our duty to our neighbour.

In a measure this principle was attended to after the Kaffir War of 1850–53. 50,000*l.* a year was granted by the Imperial Government to Sir G. Grey. This was applied to schools and missions, and to the establishment of several British Officers as residents with various Chiefs, and small salaries to Chiefs and headmen. Although the grant was withdrawn in about four years, its results were a peace for upwards of twenty years, at length unhappily broken in 1877, owing, as I shall presently show, to a constantly unstable, shifting policy in our dealings with the natives: this instability, however, being less intentional or caprice on our part, than the natural result of a system, or want of system.

But I cannot too strongly urge that the native element is one which cannot be got rid of, they cannot be extirpated—they will always be vastly superior numerically to the white man. They are not a race who will cringe and cower before the white man. From intimate personal acquaintance with the Kaffirs I can assert that, if a system be inaugurated which will win their confidence and respect, they will become peaceable and eminently useful; but every succeeding war, costly as it is in blood and treasure, will render another war more and more probable, and the chances of our ever regaining their confidence more and more remote.

I have said that the South African military aspect is the native question; and, for a thorough understanding of this native question, it is necessary that I should introduce some of the history of the

Cape, the Free State, and our recently acquired territory, the Transvaal, as well as some of that with which I have a more intimate acquaintance—our native policy on the Cape frontier and at Natal.

In the acquisition by the Dutch Boers of that vast territory of the Transvaal are some of the darkest episodes that have ever stained the history of any race wearing a white skin; and the disgrace to a great extent recoils upon our heads, for the Boers were our own subjects, whom with full knowledge of their propensities and principles we deliberately released from their allegiance, and let loose upon the black races who formerly occupied those regions.

When we took possession of the Cape Colony from the Dutch in 1806, we found slavery existing; it was abolished by us in 1833, which, together with some unnecessary concessions by us to the Kaffirs, so annoyed the Dutch, that, between 1835 and 1837, upwards of 1,500 Dutch farmers sold off their farms and trekked with their families and stock across our boundary, the Orange River, *taking their slaves with them.* An eye-witness to all this, Captain Harris, of the E. I. Company's service, writing in 1838, observes:—

"Taking a political view of this important feature in the Colonial "history, it cannot but appear extraordinary that so large a body of "disaffected subjects should have been permitted to detach themselves "from their allegiance, and cross the frontier in open defiance of "existing laws, taking with them their slaves, and forcibly entering "the territories of an ally for the avowed purpose of establishing "themselves in a position where they might shortly become the most "formidable of our enemies. Thus far their course has been marked "with blood, and with blood it must be traced to its termination, "either in their own destruction or in that of thousands of the "native population of Southern Africa."

In 1848 Sir Harry Smith required these Dutch emigrants to acknowledge their allegiance to the Queen, as their merely crossing the boundary could not absolve them from it nor denationalize them. On their declining, he fought an action with them at Boem Plaats, and annexed the whole of the country between the Orange and Vaal rivers, calling it the Orange River Sovereignty.

I do not class as unprincipled desperadoes the whole of these discontented Dutch. In our method of effecting the abolition of slavery, they may have had some fair grounds of complaint. When national feeling is aroused on freedom and justice, the British nation is apt to fly to extremes; and just at that time, the instability and shiftiness of our Kaffir policy, sometimes harsh, sometimes sentimental, had rendered the Dutch apprehensive and disgusted, just as it does the Kaffirs themselves.

But the more restless members of this Dutch community, as early as 1836, crossed the Vaal River, and were creeping along the mountains towards the Limpopo, destroying, enslaving, or pushing before them the ill-armed tribes, who, entirely without firearms, were no match for them in an open, easy country. Among those that retired were the Matabili, a large branch of the Zulu nation, under Moselekatse.

In January, 1852, the British Government, who were becoming a little tired of the Kaffir War, granted those Boers who were already north of the Vaal River permission to manage their own affairs. We disclaimed all alliances with the natives north of the Vaal River, and on their part these farmers were "not to permit the practice of "slavery!" What a Convention to enter into with members of a community who had repudiated their allegiance and left us (*taking their slaves with them*) because we had abolished slavery in our dominions, and whose servants at the date of the convention were all slaves!

However, thus was formed the Transvaal, or South African Republic.

What could be expected? The ink of the Convention was scarcely dry, when 400 of them attacked Livingstone's mission station at Koloberg. At page 39 of his Travels in South Africa, Dr. Livingstone says:—

"Boasting that the English had given up all the blacks into their "power, they assaulted the Bakwains, and, besides killing a con-"siderable number of adults, carried off 200 of our school children "into slavery, my stock of medicines was smashed, and all our "furniture and clothing carried off and sold at public auction to pay "the expenses of the foray!"

In 1854, after the Kaffir War, three Commissioners were sent out from England, and, in obedience to the popular outcry at home, said that we had too much territory. The district between the Orange and Vaal Rivers was handed back to Dutch rule, and this became what is now "the Free State."

I will not offend your ears with a recital of the sufferings of the native tribes, and the enormities perpetrated under the so-called Government of the Transvaal, as revealed in the Blue Books (see especially 1868 to 1872), suffice it to say that their system was, first a reconnaissance of a given district, and a Treaty with the tribe to which it belonged; then a raid upon it when the people were quite off their guard, and scattered among their gardens; the shooting of the men without mercy, and the carrying off the women and children for sale in the towns, where they fetched from 15*l*. to 20*l*. per head. In 1871 it was estimated that about 4,000 women and children were in slavery in the Transvaal, and, commencing with the Griquas on the west of the Free State, northward to the Limpopo, and even beyond it, thence eastward to the coast, and then southward to and including the Zulus with whom we are now at war, all the tribes were imploring the Governments of Natal and of the Cape Colony to take them as British subjects, and to send British Officers to reside among them to protect them from the Boers.

At page 127 of the Blue Book of 1869, I find the following resolutions passed by the Legislative Council of Natal, on the 10th August, 1868:—

"That ever since 1848, the emigrant farmers who settled over the "Vaal River, and formed a Government of their own under the style "of the South African Republic, have carried on a system of slavery

"under the guise of 'child apprenticeship,' such children being the "result of raids carried on against native tribes, whose men are "slaughtered, but whose children and property are seized, the one "being enslaved and sold as apprentices, the other appropriated.

"That the existence of the system of slavery, attended as it is by "indescribable atrocities and evils, is a notorious fact to all persons "acquainted with the Transvaal Republic. That these so-called des-"titute children are bought and sold under the denomination of "'black ivory.'

"That as a *bonâ fide* enquiry to be instituted by the Government of "the Transvaal Republic would be, under the circumstances, quite im-"practicable, it is highly important that Her Majesty's Government "should take other steps to ascertain the truth and to put a stop to "the trade, which, however profitable to the Boers, is a direct breach "of the Treaty entered into with Her Majesty's Commissioners."

The British Government had, it seems to me, no other course but to annex the Transvaal, and bring this hideous burlesque of a Government under control.

The only question is, why was it not done before? We now take over territory saturated with blood, dripping from the hands of men whom we in the first instance let loose. Let us be careful to pay early attention to establishing a just and merciful policy towards the native tribes, which shall be worthy of a Christian nation, and endeavour, so far as we are able, to make amends for all the blood which has been shed.

As regards the Basutos who live east of the Free State, the remnants of their tribes, who sixty years ago were broken up by wars, and living in caves and fastnesses, were united by the late Chief Moshesh, and form a large and powerful tribe. We had a short campaign against them in 1852–53, and did not altogether come off with flying colours. But Moshesh got embroiled afterwards in boundary disputes with the Free State, and in 1861 was shrewd enough to entreat that he and his people might be taken over as British subjects. He continued urging it until 1868, when his request was acceded to. "Since then," I quote from a recent lecture at the Colonial Institute, by the Clerk to the Legislative Assembly of the Cape Colony, "civilization has made marked advance among them. "Commerce and agriculture have there, it is said, gone hand in hand "with Christianity and cleanliness. Not less than 2,000 bales of "wool, and 100,000 muids of grain have been exported in one year "from Basutoland, whilst merchandize to the value of 200,000*l.* had "been imported. These facts augur brightly for the future, showing "that they are an industrious thriving people, fond of trade, and of the "comforts and conveniences it places within their reach."—(Suppt. India and Colonies, February 22nd, 1879.)

Thus much for the Free State, Transvaal, and Basutoland. I now turn to the history of our dealings with the Kaffirs and Fingoes of the Cape frontier, and the Zulus of Natal.

Not long after our taking possession of the Cape, we, expanding eastwards, met the Amaxosa Kaffirs moving westwards, driving the

Hottentots before them. By a Treaty with the Kaffirs of 1817 the Great Fish River was made the boundary between us. Graham's Town and Lower Albany were peopled by a batch of settlers in 1820.

From this time to 1850 the history of our dealings with the Kaffirs exhibits the policy of one Governor modified or reversed by the policy of his successor, or by orders from home; Treaties made and arbitrarily revised, not to say broken, when we found they did not suit us: the Kaffirs brought under British rule by one Governor, and declared independent again by the next; boundaries shifted backwards and forwards as if we were at play. Two important wars, by the first of which any opportunity for good which we had secured was thrown away within a year by a change of Governor and a reversal of policy; and in the second, also, just when a satisfactory conclusion promised, the Governor was recalled, operations stopped, and peace given to the Kaffirs who had not asked for it.

On the part of the Kaffirs there had been, as the prime cause of the trouble, much cattle stealing, over which, however, the Chiefs of these tribes have very little control. Unlike the despotic Zulu form of Government, the patriarchal rule of the Cape frontier tribes has no organization with which the Chiefs can satisfactorily repress thieving. They can punish a thief if they catch him: but a thief generally comes from a long distance from another tribe, and taking his booty through the countries of other tribes, seeks to leave the suspicion on as many as he can before he re-enters his own; for the first district he enters is responsible, until they can trace the spoor into another. Instead of endeavouring to help and educate the Kaffirs in these and other matters (as we did later), we were continually demanding of them to act as if they were possessed of a perfect organization, or as if it were at all possible for them to frame one for themselves.

After the war of 1846 a move was made by us in the right direction. British Commissioners were appointed with the Kaffirs. Mr. Charles Brownlee, the son of a highly respected missionary, was appointed to the Gaika tribe, and Colonel Maclean, formerly of the 27th Inniskillings, one of the most strictly truthful and straightforward men I have met, was appointed to the H'lambies; and there was a Chief Commissioner resident at King William's Town; while the country between the Keiskamma and the Kei was called British Kaffraria, and brought under the Crown, and thus the Colonists were no longer in contact with a purely Kaffir so-called Government.

But an unsought peace on the top of old sores could give little chance of immediate success to even the best arrangements; and in December, 1850, another war broke out. In this war, begun under Sir H. Smith, and concluded by Sir G. Cathcart, the Kaffir tribes, including those across the Kei, suffered severely in the long run, but did not succumb; our troops also had several serious disasters, and Sir G. Cathcart was ordered, from home, to make peace at any price. We also had a brush with Moshesh, the Basuto Chief, but, as we came away much satisfied with less than we had demanded, I did not think that we had won a victory. Sir G. Cathcart met Sandilli and

other Chiefs, and, in compliance with instructions from home, arranged a peace, which was proclaimed in March, 1853.

Though I shall have hereafter to revert to matters that occurred during Sir G. Cathcart's time, I now come to a period when I became more intimately acquainted with Kaffirs and Kaffir politics.

The peace of 1853, as I have said, was again a patched-up peace; but the appointment of British Commissioners had had its effect upon the Kaffirs, who learned to admire and respect them, but in a couple of years some of the Chiefs again wanted war. This time the originator was Kreli, the paramount Chief, who lived far from the English, of whom he knew nothing, beyond that he and his tribe had often been attacked by them, and that in 1835 they had killed his father, Hintza, and cut off his ears, and that, in engagements with the Kaffirs, the English had often suffered reverses. He therefore contemplated an effort on a large scale, in which the whole of the frontier tribes should be united against the English, whom he thus hoped to drive into the sea. He communicated first with Umhala, the Chief of the H'lambi tribe, and the machinery they devised was novel in the extreme, and proved more than they were able to manage.

About this time, however, Sir G. Grey was appointed Governor of the Cape, and 50,000*l.* a year was granted by the Home Government to solve the native question. Sir G. Grey was one whose great forte was dealing with uncivilized races. He showed that he sympathized with them, and that he was ready to make fair allowance for ignorance, and at the same time he sought to elevate them. Among his first measures were his aiding missions and schools, and sounding the Chiefs as to their willingness to receive British Officers, who should reside near them, and that for a fixed salary, paid monthly, they should hand over to the Government the power of levying fines, and that all cases should be tried by the Chief in presence of the Officer residing with him.

I was the first appointed; and Umhala, who was the oldest, and considered the most astute Chief, living in what might then be called the heart of Kaffirland, was asked to receive me as the representative of the Government. I think it necessary to trouble you with some of my experiences; for, during the three years that I and my wife lived among them in somewhat trying times—for the first eighteen months some thirty miles from the nearest town—I had excellent opportunities of studying their character and learning their views; and I formed the opinion, which I still hold, that the bulk of the people, if properly treated, will readily attach themselves to an Englishman, or to the Government, in preference to their own Chiefs.

As Umhala, when he was asked to receive me, was in communication with Kreli as to the feasibility of getting up a general rising against the English, he felt himself in a difficulty. To refuse point blank, he thought, would be to exhibit his hostile disposition; to accept me would be to have some one who would see more or less of his proceedings, and mar the plans before they were ripe. While professing, therefore, his great love for the British Government, he suggested all manner of difficulties, but at length was rather silenced

than induced to consent, and we were left with two tents near a new mission station, within half a mile of his kraal.

We had not been a fortnight there before I began to make friends —men who never left me. Umhala set himself to try to get rid of me, to starve us out, to terrify us by demonstrations, and at last waylay me, and to get his people to murder me. At the same time, the plan devised by himself and Kreli was developing, and from among his people my friends and adherents increased.

When the Chiefs are really planning a war, a prophet is always set up, to feel the pulse of the people, and to fix their attention. Accordingly, a prophet appeared in an out of the way place in Kreli's country, who after a time ordered that the Kaffirs should kill all their cattle and destroy their corn, and held out that they were to receive from their ancestors who were to arise a new and better quality. Those Chiefs who were let into the secret went through all the pantomime of receiving the news with displeasure and discredit, gradually coming round to believe in it: then they killed a head or two of their own cattle, and sent the rest away to distant parts of the country: then they began to urge the people to kill their cattle, and to persecute by witch doctors and other means those who did not, sometimes resorting to murder. Umhala also set up a branch prophetess, and by degrees their prognostications began to indicate something unpleasant for the English, but they were sufficiently guarded to say that it was the *new* people, their risen ancestors, and not the existing generation, who would do the fighting.

Many believed because they thought that their Chiefs believed; others complied through fear; others came to me and asked if the Government would protect them if they followed my advice.

The object of the plan was to bring the whole of the tribes *simultaneously* to the eve of starvation, and then to hurl them on the Colony, telling them that the English cattle and corn were theirs. The result was, however, that half of the people were brought to starvation point, half the remainder were hesitating, and the rest had set their faces against the orders of their Chiefs and looked to the Government. Then commenced, amongst themselves, wholesale thieving and open robbery, sometimes headed by Chiefs, and then, with Sir G. Grey's permission, I drew together to one side of the district all who leaned to the Government, and I obtained permission to organize from among them a hundred police, for whom I received arms and ammunition. Though these were a paid nucleus or reserve, the whole community would turn out for me. I abolished the name and powers of *chieftainship*, and substituted *headmen*, who, of course, were men of position—often petty Chiefs—but the difference lay in their drawing their powers from the Government through me. In a few months I had broken up all the numerous thieving bands that had been formed from the *débris* of the tribes, and, solely with my Kaffirs, caught and brought to trial on various charges of treason, robbery, and murder, some eighteen Chiefs and principal men of various tribes. Umhala had taken to the bush with a gang of his own, and I made three very good but unsuccessful attempts to catch him.

During my absence, however, on a patrol, one of my headmen, Um Juza, hearing of his whereabouts, made an expedition, with about half a dozen men, captured him and lodged him in King William's Town jail. This man, Um Juza, a most intelligent, quiet, well-meaning man, was afterwards shamefully maltreated by a number of English and Germans from King William's Town, and he has not received the protection he deserved.

After the breaking up of the tribes by starvation, when matters were looking as if they might settle down without a war, the Indian Mutiny broke out, and Kreli was not slow in endeavouring to make a handle of it. He sent round to all the Chiefs to say that their ancestors were fighting for them across the sea, and that now was the time to make a rush upon the Colony. Sir G. Grey at the time had just despatched one or two regiments to India and was wishing to send more, but thought matters so serious that he did not contemplate doing so, unless he felt himself able to strike Kreli a blow at the same time. I offered, in the condition in which I then knew Kreli to be, to expel him with my Kaffirs alone, and afterwards to locate them on the Bashee, on the further border of the conquered territory, as I had now complete confidence in Kaffirs, among whom I had connections or subjects of every Chief in Kaffirland, as well as some of Kreli's own family.

Sir G. Grey assented, and offered me a regiment of German Cavalry as a support; but, eventually, I agreed that the movement of men in military uniform would look too like a war, and a portion of the Frontier Armed Mounted Police, under Commandant Currey, was substituted. Kreli was driven across the Bashee, and, deserted by most of his followers, became a refugee with the Chief of a small tribe.

A paramount Chief like Kreli, the head of all the Amaxosa tribes, I can only compare in his influence over the people to a queen bee. There is an attraction which circumstances may partially break, but, so long as he lives, we must be more or less liable to his schemes, unless we can secure his good will or his person. Good will, I need scarcely say, is seldom to be expected from any uneducated paramount Chief, unless he be in sore need, as in the case of Moshesh. For these reasons I was anxious to catch Kreli, but I was not permitted to cross the Bashee. I was at length authorized to say, that Kreli would be permitted to live unmolested with Mony, the Chief with whom he had taken refuge, but that he would not again be recognized by the British Government, and that any communication he wished to make must come through Mony to the magistrate, whoever he might be, who might occupy my place.

Leaving the bulk of my force on the Bashee, under Colonel Colley, I then returned, according to my programme, to bring their wives and families and the remainder of the tribe from the location which had been assigned them near King William's Town, and place them on the Bashee River.

This they did not agree to without considerable reluctance, and then only on certain conditions.

The objection of one headman, named Undai, who, with his people,

refused to migrate, I shall never forget. It was a true picture of English policy, and I have learned bitterly to regret that I ever allowed myself to be the medium of any official promise, under the existing system of managing native affairs. I was descanting on the promises of protection, and pay for headmen, which I was authorized to make, and upon the fertility and advantages of the new location on the Bashee, when Undai replied:—

"I am older than you are and have seen many changes. When you "brought us here, nearer to King William's Town, it was a move in "the right direction—nearer to the English where we are safe, and "have many advantages: I don't doubt but that you mean and "believe all you promise about protection, English laws, a magistrate, "&c., but, in a few years, Government will think something else, and "we shall be left to ourselves on the Bashee, far away from the "English, to be plundered by other tribes, to quarrel among ourselves, "and to pay away our cattle to recover our credit among other "Kaffirs. I won't go—I don't mean any opposition, but I had rather "stay near the English."

And so it proved. I followed my regiment to India, leaving Colonel Colley on the Bashee, under whom the tribe continued to prove their loyalty. Among other acts, they hunted up and killed a Gaika Chief of high family, named Tola, a man of great notoriety as a warrior against us in several wars. Colonel Colley, however, left in his turn, and Sir G. Grey had left, and when I returned, some four or five years later, on the staff of Sir P. Douglas, we found a war scare commencing. A party of police, kept in the Transkei for the protection of that district and the support of the magistrate, ignoring the magistrate, had, with or without the consent of the Governor, entered into direct communications with Kreli. This was at once recognizing Kreli again as a Chief. Startled and apprehensive, many of his people flocked to him. Kreli's own version, through the magistrate and Colonel Maclean, the Lieutenant-Governor of British Kaffraria, was that he was alarmed at the messages and movements of the officer of police, who had, moreover, ordered him, Kreli, to come over and talk to him. The police version was that Kreli's attitude was very menacing—that the police were in a very critical position, that a collision was imminent, and that troops must be sent to support them.

The High Commissioner was naturally embarrassed between the two accounts. He wished, above all things, to avoid a war, and here were two doctors prescribing different modes of treatment. He gave his confidence to the police, and requested the Commander of the Forces, who was at Cape Town, to move troops to their support. Now, the country between the Kei and the Bashee had never been proclaimed British territory, and the Kei was our boundary. The Commander of the Forces, therefore, replied that he was quite prepared to defend the Colony, but without preparation and very definite aims and instructions, he could not move troops across our boundary to precipitate a war, but that he would himself at once take up the reliefs for Natal, and if the situation were really serious he could land

at East London. On arriving at East London things seemed in *statu quo*, and the troops went on to Natal. As I expected, when the police were told to be quiet, Kreli became quiet also.

But the High Commissioner's powers are absolute, and he has no one to share with him the responsibility of his acts. He may, indeed, hold those whom he chooses to consult responsible for their opinions; but both he and they know that their responsibility ends there, while the whole onus of the action taken rests on the High Commissioner. I can conceive few things more embarrassing than for a man, with no previous knowledge of a complicated native question, to have to choose a line of action for himself, between the conflicting opinions of those who are supposed to be authorities on the subject.

The High Commissioner now took a middle course. Kreli was invited to come back and occupy a scrap of his old territory, adjoining my people, who, under the orders of a former Governor, had turned him out. A corner of the territory granted to them was cut off to make room for Kreli; and, in fact, I was only just in time to explain matters to his Excellency, and to prevent their being deprived of the presence of a magistrate, and moved *altogether* out of the whole of their location into a very indifferent piece of country. About the same time, also, a large body of Fingoes, and another body of Tambookies, were persuaded to leave the Colony, and were placed in another choice part of Kreli's old country, the avowed object being *to get the whole of the natives, Fingoes and Kaffirs, out of the Colony, and beyond our boundary*, which was the Kei River.

But a tale attaches, also, to the move of this portion of the Tambookie tribe beyond our boundary. They occupied within the Colony a very nice location called Buffalo Doorns, and the High Commissioner, acting under advice, asked them to go across the T'somo and the Kei, into a part of the country that had belonged to Kreli, and which the Governor would now give them. "Is it his to give?" was the shrewd reply, meaning "If you will not first declare it to be "British, it must still belong to Kreli."

Now the history of the location called Buffalo Doorns, which it was sought to persuade them to vacate, is curious. In the war of 1850–53, the portion of the Tambookies to whom it belonged sided with the British Government, but, as another branch of the tribe joined the war party, the Queen of the tribe, widow of an old Chief, and all the peace party, moved away to a distant unoccupied territory, to avoid being mixed up in the war, and notified to the Governor why they had so done.

But, just before the war broke out, a party of farmers and traders had, entirely on their own account, extorted from a petty Tambookie Chief what they called a Treaty, that the Tambookies should move away from this land. When, after the war, the faithful portion of the tribe returned, Sir G. Cathcart reinstated them in their old location, giving to the Queen, whom, among many other compliments, he styled "the loyal faithful Regent," and her loyal tribe, a formal grant of their old location, Buffalo Doorns. Upon this, the aforesaid English and Dutch Treaty makers appealed to Sir G. Cathcart on behalf of

what they called their "Treaty," and respectfully prayed that he would not allow those vagabond Tambookies to settle again in Buffalo Doorns, but that he would grant that district to his humble petitioners. In reply, Sir G. Cathcart, after a severe rebuke for their presumption in talking of their having made a "Treaty," and informing them that they had committed an unlawful act of aggression of a very grave nature, told them to remember the tenth commandment, and not to covet that which was their neighbour's, even if it should be Buffalo Doorns.

But it was one of those men, who in 1852 had extorted the so-called Treaty which Sir G. Cathcart condemned, who was now, in 1865, persuading the High Commissioner that the Tambookies were quite willing to remove from Buffalo Doorns.

Accordingly they were told to go, and, on their demurring, they were told that if they did not go they would be turned out; and, when they still refused to go, the Civil Commissioner assembled the whole of them, on the 25th November, 1865, and informed them that, by the Governor's orders, such and such changes were made. The terms on which they had been formally granted the location by Sir G. Cathcart were upset; the Queen and petty Chiefs were reduced to the ranks, the pay of certain headmen who had specially opposed to move was stopped, and lastly, they were told that any kraals in the location which became vacant were not to be re-occupied, so that in a few years they would all be ousted from Buffalo Doorns.

This locating of part of the Tambookies, the Fingoes, and Kreli, in the old territory of the latter beyond our boundary, must be looked upon as the cause of the late outbreak with Kreli. In a letter to the Cape papers in February, 1873, I pointed out that, if Kreli were not at once plainly warned that we would allow no disturbances near our frontier between himself and others whom we had placed there, the Colony would be involved in a war within six years. The war came in five years; but it made all the difference to the Kaffir mind that one Governor had declared that the Kei was our boundary and Kreli independent, and that it would be all the better for us if those tribes beyond our boundary came to blows; that another Governor had only feebly remonstrated when Kreli attacked the Tambookies, and a bloody war ensued between them; while a third brought him to book most unexpectedly for proceeding to avenge upon the Fingoes a gross outrage perpetrated by them upon a party of his men, some of whom died of the ill-treatment they had received.

What I said then, I repeat now. The whole of our policy is shifty and unstable, and keeps the Kaffirs in a constant state of apprehension and irritation. It arises from the sole responsibility of action being vested in the High Commissioner. Each Governor acts as he thinks for the best; but his opinions are guided very much by the party or section in the Colony upon whom he chooses to rely for information and advice. The official theory of one party, publicly avowed before the outbreak of the recent war with Kreli, was, "there is no such "thing as an independent Chief between this and the Zambesi;" and, upon the strength of this, Kreli was attacked in his own country; but

without pronouncing which theory is right and which wrong, there are very few who do not know for a fact that the administrator who placed the Fingoes and Kreli in that position avowed just the opposite.

I think it is well that Kreli has been driven out and his power broken, for we had restored to him that bit of his old country, and he had accepted it thankfully; and, though he never anticipated that his attacking the Fingoes would involve him in a war with us, he knew that he was going against our wishes. But what I do regret is the policy which led to it, and the manner in which it was begun, which resulted in severe injury and injustice to other tribes and portions of tribes, who were terrified into resistance by the action of the Colonial irregulars, and shot and plundered wholesale. All the advantages of a 24 years' peace were destroyed in a few months, and it will be a long time before our frontier Kaffirs will place any confidence in our Government. I have seen a letter from a Christian Kaffir as well written and expressed as an English gentleman could write. He was in great peril from both Colonists and Fingoes, and, in speaking of the ease with which the Kaffirs had been overcome in comparison with the resistance which they had been able to offer in previous wars, he said that it had been much discussed by the Kaffirs, and that they attributed it to their totally unprepared state, as they had never contemplated war.

Of the Fingoes I need only say that they are of Zulu origin, and were refugees among the Amaxosa tribes from the tyranny of Chaka, grandfather of Cetewayo. They were as a rule kept under, though not actually ill-treated, by the Kaffirs. They came over to us in large bodies in our various wars, and have always been loyal. They are industrious, and thrifty, though very little has been done to improve them.

I find, however, in the "Colonies and India," of the 22nd March, 1879, a notice of a missionary, said to be an Africander by descent, who, writing to one of the papers, complains how our policy estranges the natives, and states thus: "Even the Fingoes feel that their tenure of "land is only safe till it suits us to tell them that they must make "room for our settlers."

I have dwelt thus far upon our dealings with the natives, because I consider it essential to a thorough knowledge of the native question. I have shown how uncertain and shifty has been our policy for nearly fifty years, more than a quarter of which has come within my own experience. I could supplement what I have stated with many more details.

I could also take more time than could be spared in showing how faithful, grateful, and yielding, Kaffirs will show themselves when you win their confidence; and I will now proceed to suggest the remedy which, in my humble opinion, will considerably modify "the military "aspect," and lead to the contentment and security alike of the Colonists and the natives.

First, then, the present powers of the High Commissioner should be vested in a standing Council, say of six, these selected from the

officials of the different Colonies for their high integrity and general knowledge of native affiairs. Their names should be approved by the Secretary of State.

Second. The Governor, who would be *ex-officio* President of this Council, should be able to veto a proposed measure, pending reference, but not to carry one out without a majority.

Third. War, or movements of troops, if affecting the natives, to be only decided and ordered by the Governor in conjunction with this Council.

Fourth. Magistrates with native tribes should be carefully chosen and the present numbers increased; they should not be moved from one tribe to another without a strong reason.

Fifth. One or two of the clerkships which would necessarily be attached to the Council, and clerkships with the various magistrates, should be open to educated Christian natives, many of whom are to be found who would be quite competent for the post, and thus inducements would be offered to the natives generally to improve themselves.

By such means I think a sound system would be secured. Instead of changing with the Governor, the Council would live on. A new Governor, instead of seeking about for, and choosing whom he would trust for information and advice, would find everything to hand, stable and ready made; faithful records of the past, which with a standing Council would not be overlooked nor forgotten, and a vast weight of responsibility off his shoulders. Business would thus be carried on in a comprehensible manner from one Governor's term to another.

The next point is schools. Short, for the present, of actual compulsion, every effort should be made to get natives to send their children to schools. Grants should be made in aid of schools in every native location. But one point must be insisted upon in these schools, viz., *the Word of God must be taught;* otherwise every evil spirit now in Kaffirland will, when educated, take to it seven others more clever and wicked than its former self. Towards the latter part of my stay in Kaffirland, had there been schools, I could have got one or two out of nearly every family to attend, and, when they had seen the benefit of it, they would have been anxious to send more.

Immediately after a war important changes and reforms may be introduced without risk. At other times changes should be gradual, and introduced with tact and patience. Such customs, however, as smelling out for witchcraft should be repressed everywhere with a high hand, and both the witch doctors, and the persons employing them, as well as those aiding or abetting the proceedings, should be brought under some severe law.

Proper clothing should be insisted upon in towns, on public roads, and in all places frequented by Europeans, and should be gradually extended to the country.

No facilities or encouragement, as in Natal, should be afforded to polygamy; and one of the first duties of the proposed Council of Native Affairs, in which the various Colonies would be represented,

should be to assimilate, as far as relative circumstances may admit, all laws affecting the natives. And this brings me to—

Natal.

The Dutch emigrant farmers as early as 1835–36 made their way over the mountains to Natal, which, together with a large district south-west of it, once called No-man's-land, now Alfredia, they found almost deserted, the inhabitants having been either cleared off by Chaka and Dingaan, or having migrated towards our Cape frontier to escape them.

We took Natal from these Dutch, who were our subjects, in 1843, and most of them retired again over the mountains. At that time you might number the thousands of natives on the fingers of one hand. When I was there first in 1853–54, they were under 100,000; in 1857 they were 120,000; in 1872, 280,000, and at the outbreak of the present war they were estimated at nearly 320,000.

Had we forced ourselves among the natives we should have been bound in justice to see that locations were liberally marked off, but such was not the case. These people are mostly refugees from Zululand, from beyond the Limpopo, and from countries conquered by the Dutch; and very large tracts have been assigned to them in Natal. As they come in, they work for two or three years, buy a wife and some cattle, and settle down in idleness and ignorance, to buy more wives, for which the Legislature of Natal has provided them with special facilities, and they are of little further use to the Colony. Though in 1872 the Kaffirs outnumbered the European population 17 to 1, labour was so scarce that the Colonists were doing all they could to import labour from Mauritius and China, notwithstanding which we still encouraged these drones to flock in.

It would have been better to my mind to allow them to come and work by all means, but certainly not to allow them to settle on the land on terms which would be denied to a European labourer. But, to entitle them to the privilege of settling down to the enjoyment of freedom, and the security to life and property afforded by a civilized Government, a certificate of so many years service with Europeans might have been required of them, together with a promise, formally registered, that they would conform to outward civilized usages, and that they would send their children to school. This last point was urged upon the Home Authorities by a Natal merchant, very many years ago.

Nothing would have deterred them from coming into Natal to labour for two or three years, and, if any hesitated to settle in Natal under the above terms, they would have returned to their own country at least with some knowledge and improvements, and thus might have become the pioneers of civilization among their own people; and barbarians like Cetewayo would have found some difficulty in remaining at the head of affairs as his subjects became more civilized and independent. Had we set our faces against idle refugees, we should have taught the Zulus to carry their own burden instead of taking it up for them, and Cetewayo might possibly have been disposed of by

his own subjects with as little ceremony as was shown to his grandfather Chaka.

Our Natal natives are almost entirely genuine Zulus; the same men that you see in the pictorial papers got up with shields and assegais. When they work they work well and faithfully, and you frequently see these great strapping men employed by Europeans as nurses for their children, and they make much better hands at it than the typical Indian bearer.

It would not be within the compass of this paper to discuss the rights and wrongs of the present war. As in many cases of the kind there were two sides, both supported by strong arguments, and by the opinions of men of experience, and the High Commissioner could do no more than weigh well between the two.

The facts, however, are that we had, as our neighbour, a notoriously bloodthirsty savage, having a large well-organized standing army under his supreme control. It is true that for upwards of thirty years, ever since we occupied Natal, we have lived alongside this same standing army under the father and uncle of the present Chief, and that they were always friendly to us. But, in the mind of a savage despot, there can be no real sympathy or regard for a free Government like ours, who moreover harboured his fugitives; and both sides must admit that the question of remaining at peace with Natal was, in Cetewayo's mind, one depending rather on his convenience than on principle. Among the people, however, there was a very large peace party, because Natal afforded a refuge to them if at any time they came under the displeasure of their fickle Sovereign or Chief.

The nut to crack was as follows:—The friendly demeanour of the controller of this large army having, for whatever reasons, previous to the ultimatum, somewhat abated towards us, and certain symptoms of restlessness, to say the least, having been exhibited by him; was the Colony of Natal to be kept in an attitude of defence, with all the attendant expenses, for an indefinite period, awaiting the convenience of the savage, or was it the proper course to bring him to book at once?

In my humble opinion the suspense and risk of a waiting policy are preferable to that which would hit a man because you think he *may* be going to hit you; and the advantages of a defensive attitude would have been that it would have better developed the mind of the Zulu nation on the question of peace or war, and, in the latter case, perhaps some of their plans; while it would have afforded to us the opportunity of making suitable preparations to act with crushing effect when the die, if for war, was cast. In the meantime the Zulu nation, who have in reality been feeling for some time the tyranny of their Sovereign, particularly on the subject of his marriage laws, might have settled the question by disposing of him themselves. They would then have leaned towards the British Government for counsel and support.

By becoming the aggressors we have, I fear, shaken the confidence of the people, and given fresh colour to any rumours which have

reached them as to the uncertainty of our dealings. I attribute Cetewayo's uneasiness and suspicions, which really drew forth the ultimatum, more to the message which reached him from Kreli, and which would not fail to paint our character for breaches of promise and general unreliability, than to the cause usually assigned, viz., the annexation of the Transvaal, which, taken by itself, I do not think would have in any way displeased him, but rather the reverse.

I mention all this, however, because a large body of the people having come in, I would express the hope that they may be treated with marked kindness and consideration, in fulfilment of the High Commissioner's proclamation that we were not at war with the people. By such policy other large bodies may be detached, and I think, with a little management, the Zulus would give up Cetewayo to the British authorities.

Though every criminal has his rights, it must always be a matter for rejoicing when the power of a bloodthirsty despot has been broken; and war having been declared, it is therefore equally for the benefit of the Zulu nation and this country that it should be carried out thoroughly, and that it should not terminate, as too many Kaffir wars have done, in a patched-up peace detrimental to the Colony and this country, and misleading to the natives. When the war is concluded, a sound system of residents or magistrates with the Chiefs will, I conclude, be inaugurated, and it would be well not to allow any head Chief to be installed in Cetewayo's place, but to keep the fragments of the nation distinct, and gradually to introduce among them the system we adopt elsewhere.

It is greatly to be desired that the war should not degenerate into a protracted Kaffir war of the old type, to avoid which every effort should be made to catch Cetewayo (and I might add in parentheses Kreli also), otherwise when he sees that he is losing he will retire with many of his followers beyond the Limpopo to the other large branch of the Zulu nation.

Within our boundary, south of the Limpopo, including Zululand, but excluding the Portuguese settlement, are roughly 300,000 whites and 2,000,000 blacks. In the Cape Colony itself the percentage was, in 1875, 33 white to 55 blacks and 12 mixed. Further north the whites are greatly in the minority.

I have thus endeavoured to place before you the numbers we have to deal with, the characters and capabilities of these races, and a description of our dealings with them hitherto; and to indicate, to the best of my ability, the alteration in our system which I think would ensure a sound and stable policy towards them—one which will give them confidence. It must also be one which seeks their improvement and elevation, instead of concerning itself almost exclusively with the question of our own immediate security and advantage.

Turning now to the physical means by which we may control these masses within our territory, and maintain our extensive boundary, I trust that the Cape Colony will henceforth be able to take care of itself with that very efficient body known as the Frontier Armed Mounted Police. I cannot help thinking that it would be a mistake

to make a military body of this force. As police it has done excellent military service, and the men are engaged to serve "either within or "beyond the borders of the Colony." With Kaffirs, as well as whites, it makes all the difference. When a movement of police is made, it may only be a theft, dispute, or small disturbance, but when troops come, it is war. The Officers, moreover, if it be made a military body, will be liable to grow above the work which they have hitherto done so well, and the whole corps to become far less efficient than it used to be.

One regiment of infantry and a few artillery, primarily for Imperial purposes, at Cape Town, will, I think, be all the support necessary to be accorded.

Natal and the Transvaal will, I conclude, remain Crown Colonies for a considerable time, as there is really not sufficient English population from which a reliable Government could be formed. Their internal and external native policy should, however, come under the Governor of the Cape in Council, of which body the Commander of the Forces and the Lieutenant-Governors of Natal, Transvaal, and Griqualand should be extra members. This arrangement seems desirable: 1st. To prevent a repetition in these Colonies of that frequent change of policy towards the natives, which has done so much mischief in the old Colony; and, 2nd, to ensure a uniform policy in the native question throughout the South African Colonies so far as their relative circumstances will admit.

It is to be hoped that the system of residents beyond our boundaries, and magistrates with tribes within our Colonies, will be extended as much as possible. For the duties of residents and magistrates with natives, there are none better than British Officers, first, because they are naturally less likely to be prejudiced against the natives, and secondly, because, having their regimental pay, a comparatively small addition will compensate them for their magisterial duties, while such addition *by itself* would be quite inadequate to secure the services of any civilian of respectability. Magistrates should be required to send in to the Governors in Council sketches and reports of their districts. Those on our borders, particularly on our extreme northern borders, should be in friendly communications with the Chiefs beyond, with whom at an early period we should seek to place a resident. And no trader, traveller, or other person, should be allowed to cross the border into foreign territory without a permit, nor to enter into any communication or agreement with such Chiefs except through the magistrates.

Natal cannot be said to be a bushy country. There is a thick strip of bush parallel with the coast; and on both banks of the Tugela, and in some of the large kloofs leading into it, the bush is very dense; the rest of the country, or the greater part of, is very open. A great part of Zululand also is very open, particularly along the foot of the Drakensberg.

Should this war be concluded satisfactorily, I think that, for a year at least, four regiments should be maintained between Natal and the Transvaal; and that two, if not three, companies of each regiment should be mounted, not with all the paraphernalia of cavalry, but with hunt-

ing saddle, the present infantry boot and gaiters, hunting spurs, sword-bayonet or hunting knife, and long rifle. Their drill should be simple, and they should be a veritable mounted infantry force, with which no commanding Officer should be allowed to play at cavalry.

In three-fourths of Natal and Zululand, and in the whole of the Transvaal, mounted infantry are indispensable. Indeed, I cannot conceive anything more tedious or helpless in the vast expanse of the Transvaal territory, untraversed as yet by a railway, than a force composed solely of infantry. In the early days of Natal, the importance of a mounted force was so recognized, that the light company of the 45th Regiment was mounted, and a very smart and efficient body it was.

By first keeping their distance, a few mounted infantry can engage any masses of footmen, and play with them. It is thus that dragoons used to be taught to harass a mob, and thus a handful of Dutch Boers almost destroyed a large army of Zulus under Dingaan. The Zulus had no guns, of course; but, in the present war, the Zulus, with a few inferior arms, are relatively not in a much better position to our breech-loaders than when without firearms they engaged the Boers, who were armed with smooth-bore muzzle-loaders. But the Boers were mounted, and could keep their distance.

I know that there may be some objection to introducing such novelties as mounted companies into regular regiments; and failing the adoption of the suggestion, the Natal Mounted Police might be increased to 800 strong, or a separate body raised for the Transvaal; and, if this were done, one of the four British regiments might be dispensed with.

While on the subject of mounted infantry, I cannot forbear observing that I think, in the present war, their movements have been too confined. They seem always to have retired upon the camp, laager, or force to which they belonged, thus inviting and enabling the enemy to concentrate, instead of harassing and disturbing him. I think that, to use their special powers effectively, they should, if the country is tolerably open, discard for the time their proper base (keeping, however, some possible line or lines of retreat in their mind), and they should manœuvre, not in front of an enemy's flank, but in rear of him. With proper precautions, they run no danger of being cut off; and they should always be provided with a meal or two in their havresacks.

I think, however, that we allow a very valuable material, suitable for a most efficient force, to run to waste. I mean the native element. It gives us much trouble to take care of it, when, by utilizing it, we might keep it out of much mischief, and make it do the work more efficiently, at much less cost, than an exclusively European force. I do not mean that we could dispense with Europeans, but we might do without so many.

Before the Kaffir War of 1850, there was a body of 200 Kaffir Police. They were dressed in rifle uniform and well drilled, and for smartness and soldierly appearance they were not to be excelled. It

was thought better, when the war began, to disarm and disband them, though a few were retained as orderlies and messengers, who remained faithful during the war.

The behaviour of my own Kaffirs, in attacking and catching any Chiefs or others, when it was required of them, proves how faithful and loyal they will be when properly treated. I never strained this, however, and if I was trying to catch the relatives or friends of any of the men, I used to give such of them leave to fall out and go home, and this doubled their zeal for the next occasion. See also the excellent behaviour, at the present time, of the Basutos whom we are employing against one of their Chiefs, a notorious fellow of the old type. I fear our Fingoes and Natal Kaffirs are deteriorated with ease and comfort; but Amaxosa Kaffirs who are of higher blood, Tambookies, Basutos, and Cetewayo's Zulus (when the war is concluded) will make admirable armed police, on foot or mounted; and might be engaged to serve anywhere in Africa. Trial might be made, in three or four localities, of bodies of say 200 strong under British Officers, and our African troops might become as good and important for the needs of our Empire as our Indian troops. In the Ceylon Rifles they had for a long time a Kaffir element originally sent by the Dutch as convicts from the Cape. They were esteemed as the best soldiers in that corps. I feel quite sure that, if once tested, battalions will soon be formed.

The Transvaal will, I think, attract many more English in proportion than the old Colony has done. Zululand will, I apprehend, be kept for the Zulus, but it should be governed by its own Chiefs *under our direction*, to such an extent, and in such a manner, as may be determined by Treaty. Though an outlay may be required at first to inaugurate a sound native policy, the two provinces, Natal and the Transvaal, will very soon, as confidence is established, and particularly if railways are urged forward, yield good revenues and have a sufficient English population to enable them to manage their own affairs.

It is a neglected and mismanaged native question that has led to the present war; and it is our unstable policy, leading to injustices, breaches of faith, and such like, that is the great obstacle to all mission work and to the progress of Christianity; for the natives cannot appreciate the value of the religion of a people whose governing body deals unjustly with them. Any injustice done them has doubtless been caused inadvertently by carelessness, or want of acquaintance with the subject, but the Kaffir knows nothing about that, and a great Government of a great people professing Christianity should be sufficiently jealous of its honour to contrive a system which will prevent injustices being done through forgetfulness or ignorance.

The natives are not standing still; they are advancing in shrewdness and in a knowledge of whatever tends to their own advantage; and, in the Cape Colony, the franchise is so low as to admit of thousands of them, if they only knew it, being "free and independent "electors." If they advance thus without Christianity, the consequences are somewhat serious to contemplate. If after the conclusion of this war we again resign ourselves to scrambling along in a slovenly

manner over the native question, we shall do so at our peril. As I said at the commencement of this lecture, *the military aspect of South Africa is the native question.*

Mr. G. P. MOODIE: Being very much interested in Cape Colony generally, and in the Transvaal in particular, I have listened with a very great deal of pleasure to what has fallen from Colonel Gawler, especially when he has referred to the absence of any definite State policy on the part of the Government towards the natives in South Africa, and to that being in the main the cause of all the troubles that have arisen there. I am sorry, however, that I cannot agree with what he has said with regard to the Boers of the Transvaal. As a French journal has lately remarked, "Nothing is more atrocious than the use that people are getting into the habit of "making of atrocities, and nothing more sad than the fate of Treaties in an age "which has the pretension of having made singular progress in international law." You have had several examples of this of late, and I think the Transvaal is not an exception to the rule. Colonel Gawler has been very candid in exposing the faults the English have committed in South Africa, and in showing how much injustice has been done by them: but it is to be regretted that while injustice to natives on the part of England is called by him a mistaken policy, injustice on the part of the Boers is alluded to only as barbarity. I must also enter a most decisive and emphatic protest against the charge of slavery made against the Boers. In all probability his information upon this point has been gained from books.

Colonel GAWLER: Blue Books.

Mr. MOODIE: The most unreliable documents you could possibly have. It is a well known fact that the Boers brought no slaves into the Transvaal from Cape Colony: any one that came with them came voluntarily. The British Government would only have been too happy at that time to have taken advantage of anything which would have given them a real hold. They had applied to the Attorney-General for authority to stop these people from migrating, and he could give them none. Had they had slaves with them such a thing could not have occurred. We hear also of slaves having been sold, but I should like to ask how many slaves has Sir Theophilus Shepstone liberated in the Transvaal? I can state from personal knowledge that he has not liberated one, and from the simple and sufficient reason that there were none to liberate. With regard to the Government, I think the great defect of South African policy is that it is directed by Parliamentary Government at home. Whenever a Colonial question comes before Parliament, it is notorious the House is cleared immediately; they take no interest in it at all. I have noticed it myself on several occasions, and the most important affairs concerning the Colony are in all probality relegated to a Colonial Office Clerk. I liked very much what I heard from Colonel Gawler with regard to the character of the natives generally, and their adaptability for civilization, especially the Zulus. They have a very strong feeling of allegiance, and all we want is a transfer of that allegiance to a power superior to their own Chiefs. But to obtain that we require to show them that our rule is better than theirs. If we in Cape Colony and in Natal had always taken up that position of superiority to the whole of the tribes, and dictated to them, they would have listened to us with pleasure, and would willingly have transferred allegiance to us when they found it was to their advantage to do so. I have said what I have said as to the Boers, not alone in justice to them and because I consider it right and true, but also because I think it is most necessary in the present state of things that everything should be done to avoid raking up old and unauthenticated stories about them, and that we should rather endeavour now to conciliate them and try to get them to join us. It is wrong to suppose that the Boers left the Colony on account of the abolition of slavery; they left the Colony because they could see no future under the British native policy. The slavery question added no doubt fuel to the ferment among them then; but in reality their migration was due almost solely to their discontent with our native policy, and it is that at the present moment—I speak from personal knowledge—which keeps the Boers in that hostile attitude towards the British Government. They say that by British occupation of the Transvaal, in 40 years the Transvaal will be what Natal is to-day, a huge native

location. When we took possession of Natal there were 30,000 or 40,000 natives in it, and now there are 350,000. I fully believe that when that question of native policy is settled, the main cause of their discontent would be removed, and they would quietly settle down under British rule.

General Sir ARTHUR CUNYNGHAME, G.C.B.: In the position I held in South Africa, that of Lieutenant-Governor, as well as Commander of the Forces, it is incumbent that I should say a few words upon so serious a subject as that which has been brought before you to-day. It has been asserted by Colonel Gawler that it is the wrong way in which the native policy has been carried out that has led to these wars in South Africa. It appears to me that it is not so much to that cause as it is to two others. In the first place it is owing to the natives being so thoroughly armed as they have latterly been; and in the second place to a gradual change in the general policy which has been pursued towards them. Their being so highly armed was caused by the responsible Government of the Cape Colony not taking energetic steps to prevent the sale of arms, but rather encouraging it, imagining that no future wars would occur in South Africa. During the four and a half years that I was Commander of the Forces in South Africa the natives were allowed to purchase 400,000 stand of arms. Possessing these, they considered the time had arrived in which they could defeat the white men; and as education had not gone *pari passu* with arming these enormous hordes of black people, they could not know the power that England could bring forth, more especially as England was rather reticent in coming forward when assistance was at first called for. The natives therefore determined to seize the opportunity, which appeared so favourable to them, of driving the white man out of the country.

The second reason is that they saw by our gradual advances that the Chiefs would be compelled to submit to the same policy which was being adopted in the Colonies themselves, viz., the right to individual proprietorship. Immediately beyond the borders of the Colony all the old systems of chieftainship still existed, whereby no man could hold individual property; not only so, but amongst the Griquas in the Colony that system still existed. The fealty that these black men bear to their Chiefs is so strong, that nothing can detach them from their Chief while he remains at their head; but when proprietorship is introduced among them, then the same allegiance would be given towards the paramount Government. Seeing, then, the institution of Chieftainship drifting away in the Colony, the Chiefs on the borders became alarmed, and for the first time possessing English firearms, they determined not to let slip the golden opportunity, which they believed they possessed, of dictating to the white man the future line of conduct to which they should adhere.

At the same time the Cape authorities were so blind as not to see the dangers which were arising. The Colony could not be convinced of the necessity of providing a defensive force. Nothing could persuade them to think it necessary to have a Militia, and the Volunteer system that they inaugurated was altogether imperfect. As to their Yeomanry, it existed on paper. No power whatever existed of obliging a continuance of service for a single day, even when in the field.

I do not concur in the assertion that we attacked Kreli, the Galeka. It was Kreli who attacked those who were dependent on the British Government, the Fingoes, and not only that, but he attacked the Colonial Frontier Field Force when encamped outside his own country. He said, "Go and attack those Fingoes, and on " your way sweep off that small camp of white people." It must never be understood that we wantonly attacked Kreli; it was he who wantonly attacked us.

As regards the Boers both in the Cape Colony and the Transvaal, I have a high respect for them. They are physically an extremely well-developed set of men; their system of slavery may be considered more of a patriarchal institution—such as we read of in the Old Testament—than of the kind which we were accustomed to regard with so much horror in the Southern States of America. I regret that this should now be so strongly reverted to, except as one reason for the annexation of the Transvaal. The Zulu war can, no doubt, be traced to our annexation of the Transvaal; the question naturally arises whether that was necessary or not. In my opinion, it was a positive obligation. Had we not annexed the Transvaal, there is very little doubt that, the Boers having claimed a considerable portion of Zululand

on the Pongola River, Cetewayo was perfectly determined to attack them; we could not have stood by and allowed the white men of the Transvaal to be massacred; we must have gone forward to help them; the Free States must have done the same. Had the Zulus burned Pretoria and destroyed the whole country, we should have been placed in an infinitely worse position, after they had committed so much injury, than we were by keeping the Zulus from our borders. It was not known that Cetewayo and the Zulus were so powerful a race as they have proved to be. Again, it was no doubt considered that for dictating terms to the Zulu King the occasion was so far good, inasmuch as Her Majesty had sent out a very large excess of troops to the country, and that now was the time to bring about an arrangement with Cetewayo, and make him more moderate in his military armaments. Doubtless when Her Majesty's troops had returned home he would have rushed over both Natal and the Transvaal; perhaps, indeed, have swept down to King William's Town, and even to Graham's Town. It was, therefore, not unreasonable to desire to make such terms with Cetewayo as that he should lessen his military forces and accept an improved form of government. Before the annexation, the Boers had attacked Secocoeni and were ready to have met Cetewayo; but they had no idea of the great change which the armament of the natives had occasioned. The Dutch were accustomed in former times to sweep over the country with their long guns, and drive everything before them; and when the war with Secocoeni began, they imagined they would at once succeed as before, and clear the country; they never took into their consideration the hundreds and thousands of arms which had been sold to the natives—sold to those who came from those very countries to work upon the railroads, and who were allowed to return armed, or of the muskets sold in the Diamond Fields, where rifles purchased in England for about 1*l.* were exchanged for 8*l.* or 9*l.* worth of black labour. The Boers, owing to their isolation from the rest of the Colony, were ignorant of the power which now surrounded them, and nothing could have been greater than their astonishment to find that the natives were now better armed and more powerful than themselves; the Boers, being driven back by Secocoeni, were now forced to allow that they could in turn be destroyed by the armed black man. That was the reason that Sir Theophilus Shepstone, under the authority of Lord Carnarvon, deemed it necessary for the safety of the white race to annex the Transvaal; and in my opinion had it not been done, we should have commenced this war in an infinitely worse position than we did. For my friend, Lord Chelmsford, great difficulties were in store when he had to attack Cetewayo in the interior of his country—difficulties arising not so much from the bravery of the Zulus as from the fact that our army cannot be fed from the resources of the country; everything must be taken from the base, and also that there are very few or no roads—difficulties, however, which are not insurmountable, and which must be overcome.

With regard to the future of South Africa, some federative system must be carried out, by which military arrangements can be made for the whole of Her Majesty's dominions there, upon a collective and not so divided a way as it has been done. Unless that can be thoroughly established, I do not consider military successes, without a larger standing army from home, can be attained. At present the responsible government of the Cape is entirely free from the rest of the Colonies; Natal may be called a half Crown Colony; the Transvaal is entirely under the Royal prerogative; the Diamond Fields has a small Council; the Transkei is a country practically under Colonial government; magistrates are sent there from the Cape Colony; but it is in an uncertain state as to its government, which is most unsatisfactory; and a recurrence of all these difficulties must be expected, unless a federative system is adopted as regards the whole of South Africa, whereby a Governor should be placed over the whole, with a Dominion Parliament and a separate House of Assembly, with a separate Provincial Government for each of the Colonies. That is a paramount necessity for the future tranquillity of South Africa; and that being done, we should not be continually obliged to send assistance in men and money from England to a country which, by good arrangements, can perfectly well defend itself, they forming such a defensive force as would be most satisfactory. There are plenty of fine, well-formed young men, both English and Dutch, who could, under a good system, be taught to serve their country—a system organized much after that

adopted in Canada, both militia and volunteers, with proper regulations as to service. The regulations are somewhat stringent in the Colony of Natal, but in Natal there are so small a number of Europeans, that it is quite impossible to form a sufficient force to defend our dominions. For the border States alone, unassisted by the Cape Colony, it would be impossible to undertake the whole defence. Natal, for instance, possessing only 20,000 whites, they could not form a sufficient force to resist the whole strength of the Zulu hordes, or all the black races on their borders; nor can the obligation be fairly placed upon them of defending the Cape Colony. It is by a federated system alone that the Colonies will be able to preserve order and to maintain their integrity.

A few words have been said upon the native army of South Africa. I cannot see why this should not be a success just as it has been in India. As to the physical abilities of the natives, you may depend upon it there are no finer men in the world; moreover, they have none of those caste prejudices which have occasionally so awkward an effect in an Indian army. As to their allegiance, I believe that under good and proper arrangement, the allegiance of the natives of South Africa can be secured, and that the very best effect both to South Africa and to England might arise from the formation of an army of natives in our South African dominions.

Captain J. C. R. Colomb, R.M.A.: There are one or two practical points in the paper on which I desire to say a word. The lecturer says, "the suspense and risk "of a waiting policy are preferable to that which would hit a man because you "think he may be going to hit you." I do not think any student of the military history of South Africa can agree to this. We have heard what Sir Arthur Cunynghame, about the best authority we can have, has said, and for my own part I most certainly think that, remembering that some of the Imperial troops were about to be withdrawn, and seeing that there was no local military system at all in South Africa, had a waiting policy been pursued, the white race would have been almost swept out of South Africa. I say that because I have arrived at these conclusions from a wholly different standpoint from other people who have spoken. I have not had the advantage of serving in South Africa, but I have studied the local military history of the Colonies. Colonel Gawler says it would be a mistake to make a military body of the Frontier Armed Mounted Police. I think that is dead against the military experience at the Cape. Even in 1876 I see a Colonel, writing to a member of the House of Assembly, says it is absolutely necessary that this force should have a military constitution. Colonel Gawler says: "The Officers, moreover, if it be made "a military body, will be liable to grow above the work which they have hitherto "done so well, and the whole corps to become far less efficient than it used to be." I do not think that there is any proof of that statement, and on the contrary, Colonel Gawler himself recommends arrangement for the government of the natives by what? military Officers. Again, with regard to the actual efficiency of the police being determined in any way as police by giving them a military constitution, I, as an Irish magistrate of several years' experience, say that the Irish Constabulary is a direct contradiction to that idea. The main point to be borne in mind is this as regards the native question, we must have a settled native policy, and I do not think with our present machinery we are likely to get it. But when this present war is closed, excitement and interest in South Africa will have ceased, and there is every probability, after we have shed our blood and spent our money, things will continue shifting about as before. No matter how anxious we may be to Christianise and civilize the natives, no matter how we feel bound to treat them with justice, we must remember this, that the natives are our inferiors, and we must be prepared to treat them firmly as such. You cannot do that, armed and numerous as they are, without proper military force, to show them that you have the power, and in order to have that power in reality, you must have in South Africa a proper, well-constructed, business-like, sensible military system. Sir Arthur Cunynghame has spoken of the great military power to be derived from a proper arrangement for internal defence in South Africa, and it may be in some of your recollections that in a despatch of about three months ago, Sir Bartle Frere goes further than that, and says: "that "when this war is closed, when things are settled, not only will South Africa be "able to maintain a well-constituted military force, and to provide for her military "necessities for internal defence, but that the inhabitants and people of South

"Africa will be found as readily willing as any portion of the Empire to contribute "their quota for military service beyond the Colony, in order to carry out any comprehensive scheme of general Imperial defence which may be adopted."

Colonel ALCOCK: I should like to ask what is strictly a military question—namely, whether the Colonial Government at the Cape is still deriving revenue from the sale of arms, seeing that that has very materially affected the state of the Colonists and increased the difficulties of the war, and although at this Institution we do not touch upon political science or on the action of our own or of any Colonial Government in bringing on a war, still, as mention has been made of a recent article in the *Quarterly Review*, I may perhaps be allowed to ask whether the *Quarterly Review* is correct. According to my recollection of the article in question, the statement is that the Orange River was our boundary, but that at the time of the discovery of the Diamond Fields, we occupied a portion of the country beyond our boundary, and that that, with the sale of arms to the natives, was really the origin of the war? I would likewise ask whether the natives are, or have been, supplied with arms through the Portuguese settlement of Delagoa Bay?

Mr. PATERSON (Member of the Cape Legislature): I may mention, for the satisfaction of Colonel Alcock, that the Cape Government has put the sale of arms and gunpowder under the severest restrictions. It has been argued on one side that the wars in South Africa have sprung from the sale of firearms, and on the other side, that the wars in South Africa have originated in the want of a stable native policy, and both sides are perfectly satisfied that if they could get the whole attention to bear upon one point or the other, they would solve the South African problem. I do not agree with either; I hold that the condition of barbarism and civilization placed in contact is a normal condition of warfare. We had wars in South Africa long before firearms even reached the natives, and long before there was the shifting native policy which has sometimes taken place. You must look upon South Africa as a State with two great communities, the white and the black, struggling one with the other, and if you think that there is any less constant cause than that for the wars from 1819 to 1879, you are going on a wrong scent. I am convinced myself that the sale of firearms has had very little to do indeed with the outbreak. When Kreli, the great Galeka Chief, determined to punish the Fingoes who had previously been his slaves, or the slaves of the Galekas, as we call them, he had the most thorough respect for the British authority, and he showed this by sending his own sons to give the white men a safe conduct into the Colony. He said in so many words, "My warfare is not with the white man. I know perfectly well I am inferior to the white man, and that I should be crushed; but I object to the "Fingo; I am going to put him down, and if in putting him down I should come "in collision with the white man I will do it, so great is my dislike to the Fingo." I am convinced also that Cetewayo himself had before the outbreak of this war unbounded respect for British power, and unbounded belief in it, and that nothing else than that has restrained him for the last 20 years from breaking in upon Natal. What is to be the future? I have said distinctly, the normal condition of things out there is struggle between the black and white. If the white men are to be put into position to be strong enough against the black, it must be by union of the whole white population. Does any man in his senses imagine that a little settlement like the Transvaal, which could not muster 5,000 men altogether, not backed up by a great population, could even hold their ground against these masses of barbarism coming from the north? or do you imagine the 20,000 white people in Natal, men, women, and children, will ever be able to hold their ground there unless there is a tremendous force behind them on which they can draw for protection? If the Imperial Government think they can have a number of small separate Crown Colonies in Africa, and can maintain them by occasional displays of military force without having to pay their millions, they are quite mistaken. There is only one way in which the white man can hold his ground in South Africa, and that is by being one strong people drawing upon one another and feeling themselves committed to the position that they must hold their own.

Colonel GAWLER, in reply, said Mr. Moodie seemed to ridicule the idea of there ever having been such a thing as slavery among the Boers, and he had denied their having taken their slaves with them when they quitted the Cape Colony, because he

said they had none to take. But these are events which I think could not have come within Mr. Moodie's *personal* observation. They are matters of history, and, if Mr. Moodie believes one historian, I rely upon another; and I prefer the evidence of Captain Harris, of the East India Civil Service, who was at the Cape when we abolished slavery, and who travelled across our boundary through the emigrant Dutch, to Moselekatse, who received him uncommonly well, though at war with the Dutch.

I do not know how Mr. Moodie would get over the fact of Dr. Livingstone's statement that his station was attacked by the Boers, his medicines smashed, his clothes taken away and sold, and two hundred of his school children carried off into slavery. Most of the particulars which I brought forward to-day about the Dutch, I mentioned in a lecture which I delivered in April, 1874, at the Society of Arts; Mr. Moodie was there, and, so far from giving such a sweeping denial to them as he has done to-day, he admitted that *irregularities* had occurred. Some stories may be exaggerated more or less, and the worst atrocities may be perpetrated only by a few; but it remains a fact that there are a great many slaves in the Transvaal. If you see a black man with a Dutchman, and go into his history, you will find he is a slave. I myself, when shooting on the Pongola, was offered a girl and boy for sale; if I recollect right I was asked a 4*s.* 6*d.* blanket and pair of trousers a-piece for them. I and my companion indignantly declined, which very much incensed the Chief, but a day or two afterwards, passing a Dutchman's waggon, we saw the same girl and boy, and found that the Dutchman had not been so particular, but had bought the two. Slavery is part of a Dutchman's principle; he sees nothing wrong in it; it is a part of his creed.[1] I cannot meet Captain Colomb's observations, on the subject of what I called *the waiting policy*, without going further into politics, which must be avoided. The point is, are we to live in South Africa with the Kaffirs amongst us as our enemies, or are we to endeavour to improve them and get along on peaceable terms?

The CHAIRMAN: I have no doubt you will permit me to express your thanks to Colonel Gawler for his very able lecture. I hope that we are not, as asserted by Mr. Moodie, to be in a constant state of *warfare* with the natives. There will ever be a constant state of *antagonism* between the black and the white races, and no doubt the authority of the white race must prevail within our own borders. Our great object should be to enforce that policy with all the tenderness we can, in order that by our example and liberality and by our good sound political government we may be enabled to ward off future wars. What the future of South Africa is to be, I need not discuss here; but I do think there is great danger to the maintenance of peace with that strong warlike people beyond our present frontiers. As to the strategical aspects of that frontier, I consider our frontier to the east of the Cape to be the very worst we could possibly have. Our troops are scattered in small bodies over a semicircle about 150 or 200 miles in extent, while Cetewayo possesses interior lines, and I do not think we shall ever keep an Imperial force sufficient to maintain the existing frontier.

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[1] Much has been said about "federation" of the South African Colonies and States. It is no doubt most desirable; but the Dutch *avowed* principles on the native question differ so widely from those by which we at least seek to be guided, that it is useless to dream of federation that shall include the Transvaal, until the Dutch element there is outbalanced by the English.

LECTURE.

Friday, April 25, 1879.

ADMIRAL A. P. RYDER in the Chair.

BROADSIDE FIRE, AND A NAVAL WAR GAME.

By Captain P. H. COLOMB, R.N.

1. To Admiral Randolph belongs the honour, which. so far as I know, will be unchallenged, of being the only man in Europe who has distinctly faced a tactical problem in naval warfare. No doubt there are others, especially on the Continent, who have incidentally met and discussed various questions which present themselves the moment we leave the well-trodden path of vague generalities, and come to particular and definite facts. But it is to be observed of these authors—of whom Admiral Bourgois, of the French Navy, is an example—that their treatment of different points is only incidental and partial. If they treat of the gun as a weapon they will take up its accuracy, its penetrating effect, and perhaps its arc of training. If they take up the ram, they will show how it is governed by the curves described in turning. If they take the torpedo, they will speak of it almost as if there was no other weapon available, and certainly as if the enemy was passive. But Admiral Randolph has taken up all these points. He has assumed an active enemy replying to the attack to the best of his ability, and he has endeavoured to come to some *relative* conclusions on a single point—the best method of placing the guns on board an armoured ship.

2. I am sure the gallant Admiral would be the last to assert that he has finally disposed of the question. On the contrary, I feel confident that his wish in reading his papers was to stir us all up to further and closer investigation by the use of the methods he has put into our hands.

3. What are those methods? They are, first, the placing together and considering the relative tactical effects of *time* and *space*. Time, as it effects the covering of distances, either on a straight course, or in turning through given angles, and as it determines the rapidity of fire. Space, as it governs the approach or withdrawal of enemies' ships; as it bounds the possibility of ramming; as it interferes with the arc of

training of the guns, and the hits and penetration of the projectiles. Time and space together, sometimes in concert, sometimes in opposition, as they affect movement and gun-fire; naturally also torpedo fire, if we were yet in a condition to take up that subject.

4. Using Admiral Randolph's methods, and acknowledging very fully my obligations to him and to them, I propose to make one small advance in their application, and to see whether we shall be led to any further or different conclusions by this slight improvement.

5. Admiral Randolph assumed a space in turning and a time in turning for the two ships which played the part of examples. I propose now to substitute for these assumptions nearly the accurate results of an experiment. In the year 1877, the turning powers of Her Majesty's ship "Thunderer" were very carefully ascertained, and mapped out for several different speeds. There are niceties in the results which must hereafter come into play, but we are hardly ready for them yet. But in taking the broad results for two different speeds, and using them as Admiral Randolph used the assumed results, we are evidently on ground which is just the surer by as much as the data are nearer the truth. In any conclusions we may arrive at to-day, we may assure ourselves that in so far as they depend on turning powers at speed, they will be very nearly true for two ships similar to the "Thunderer" in smooth water. You will observe, therefore, that while we shall still, and necessarily, be dealing largely with assumptions which may be challenged as only remotely approaching the truth, we shall be resting a good deal on what cannot be challenged, except within very narrow limits. We shall get, I think, another illustration of an axiom on which I have for many years insisted, namely, that the differences of opinion which exist amongst us on the rights and wrongs of naval tactics, are removable in peace time by study and experiment. In fact everything which is going on in the naval world convinces me more and more of the growth of mechanism—if I may use the expression—in future sea-fights. We seem to be losing every day some page in that large chapter of accidents which made past sea-fights so romantic even in the dry pages of James. By consequence, we are approaching every day towards a system when the certainties are calculated beforehand, and when a ship or a fleet may mechanically and scientifically win, or be beaten, without touching, except in the persons of one or two leaders, on that splendid heritage of personal heroism which our naval forefathers bequeathed to us. It does not require any wide stretch of a humorous imagination to think, in these days of rams and torpedoes, of Officers and ships' companies in cork jackets standing by to swim for it as the fleets approach, but doing nothing else. For as, if you propose to sink the ship, the men in her are neither here nor there, you may come to an agreement to give up the destruction of life which would be the chief result of a "brutal" artillery fire, and simply play the game of ship-sinking until either side has had enough of it. Of course, in such coming times, we should have a properly organized "Blue-cross" society, whose business it would be to pick up the cork jackets which, with those in them, would be the

only *débris* of the fight. But this is by the way, and for our posterity to consider.

6. If I may venture to offer a criticism on Admiral Randolph's first paper, I may perhaps be allowed to say that I think he pushed his method too far on that occasion, and hoped to get more from it than it was quite capable of yielding in its then condition. Although we may, by the use of the Admiral's great powers, bring about a consensus of opinion on such a subject as the relative values of broadside or end-on fire, I think we should be continually reminding one another that this is not our object. It is quite possible that we may all—including the very ablest—think wrongly on such a question, and our object is to get at the actual facts quite apart from any opinions that we may hold. The effect on my mind on first reading the Admiral's paper was, that in supporting broadside fire as I had done, I had gone beyond the facts, and could not offer a sufficient defence to the Admiral's end-on attack. But when I began to analyse more closely, I could not help feeling that much of his apparent superiority was due to a skilful use of elements in the combat which he disallowed to his opponent. He appeared, for instance, to permit himself a command of regulation of speed, which his opponent did not exercise; and in the case of the ram, he gave himself a superiority which does not appear to me to be inherent in that weapon. Many years ago I endeavoured to show in this theatre that the difference between ramming and being rammed was exceedingly fine, and was in fact a question of very few seconds in time, and very few yards in space. I venture to think that this point was not altogether as present to the Admiral's mind, throughout his hypothetical combat, as it is to my own. I found in short—or perhaps I should say I thought I found—that all the results arrived at by the Admiral were not supported by a still closer investigation, and a still more rigid adherence to ascertained facts.

7. As I am not here making a reply to the gallant Admiral, but really following out the methods he has proposed to some of their conclusions, I shall not now follow him further, but will merely note that if the discussion takes the peculiar form which I shall have the honour of suggesting, the points to which I have adverted will naturally work themselves to the front.

8. I think the problem before us at the present epoch of naval progress was correctly stated by the gallant Officer in his title, and I may perhaps be allowed to say that, in the discussion which followed, there was a difficulty in dealing precisely with that problem, and no other. The question is, the *relative* importance of broadside as compared with end-on fire. Everyone would perhaps agree with Admiral Phillimore's dictum that no one in these days would attempt to arm a ship without providing *some* end-on fire. But this being so, the real question is "how much end-on fire, seeing that in most cases you "take it away from the broadside fire?" The gallant lecturer took a typical ship of 12 guns, and gave it as the result of his investigations that one-third of these guns may be advantageously taken away from the broadside in order to fire right ahead and right astern. But we

need not go to hypothetical cases to see how opinion sways and varies in our Navy, and how it determines the expenditure of vast sums of the public money first in one direction and then in another, as the Service inclines to what I may term, for shortness, my view, or to the gallant Admiral's.

9. Go to the "Warrior," "Black Prince," "Resistance," "Defence," "Hector," and "Valiant;" "Achilles," "Northumberland," "Agincourt," and "Minotaur"; "Royal Oak," "Caledonia," "Ocean" and "Prince Consort"; "Enterprise," "Favorite," "Zealous," and "Research"—that is, to the series of ships ordered from 1859 to 1863—and we have only very faint indications of an opinion in favour of end-on fire. But take the later ships from 1863 onwards, and you can see as in a map the growth of this opinion. We get it faintly in the "Lord Warden" and "Lord Clyde," ordered in 1863; more strongly in the "Bellerophon," where two $6\frac{1}{2}$-ton guns represented the end-on fire, as against 10 12-ton guns representing the broadside fire. In a later ship, the "Hercules," the end-on opinion has gained strength, and we find the end-on fire represented by 4 18-ton guns, and 2 12-ton guns out of a total armoured force of 8 18-ton and 2 12-ton guns. But in the "Hercules" and "Sultan" the opinion was not strong enough to actually *withdraw* guns from the broadside. Arrangements were made by which the Captain might at his discretion follow Admiral Randolph's opinion or mine. Extra ports and some extra weight of armour were the sacrifices then thought proper to make to the end-on idea. But in a few years the idea is bolder, and it builds the "Audacious" class, where—but for an enlargement of end-on ports, which we have not yet admitted on the broadside—4 guns are withdrawn from the broadsides of 10, and given up to end-on fire. We now go on a little further, and we come to the "Alexandra," where the end-on idea has made a great step. It is here not only a question of withdrawing from the strength of the broadside, but actually throwing it into the background by placing specially heavy guns as end-on guns. She carries 6 18-ton guns on the broadside, and she carries 6 end-on guns, but of these, 2 are 25-ton guns.

10. Yet the end-on idea is far from being content with its victory over the "Alexandra." It went two steps further, invaded a new province, and took away the armour from the sides of the "Nelson," "Northampton" and "Shannon;" then invaded another new province, made a dash at the turret system, and, aided perhaps by other considerations, it put the turrets of the "Inflexible" at an angle to the line of keel.

11. Thus the end-on idea, not making its practical appearance until 1863, has gone on enlarging its borders until it has insisted that even our turret system was wrong, and I know not now whether it will be content with practically reversing our ideas of fifteen years ago, or whether it wants still more!

12. But what are the causes of this wonderful change of opinion? We surely ought to be able to appeal to some definite results, either of experiment or argument, which have so decided the case in favour of

the end-on fire. Yet I believe it must be stated that there were no such things before the Admiral read his first paper here. We have the statements of opinion—vague and general—on record, and we have the effects of the opinion in the ships I have named, but we have in support of these tremendous results, only the Admiral's paper in the form of argument, and nothing that I know of in the form of experiment.

13. But Admiral Randolph's argument only goes, after all, as far as to say that the relative importance of broadside and end-on fire is as 3 to 1; we have not had his views on the question whether he would sink the level of the broadside below the level of the end-on fire as in the "Alexandra" or but on an equality with it as in the "Inflexible." So we see that if even we admitted every word of Admiral Randolph's allegations and accepted his arguments in full, we should still be lagging behind the actual facts which are before us, solid and unyielding in the ships I have named.

14. I am only too well aware that the language I am using will be construed into an attack on our naval policy so far as construction goes. If I am attacking anything—which I take leave to doubt—I am attacking the active service of the Navy, not excluding myself as an humble member of it. It is from us that the ideas have come, the embodiment is no doubt independent of our control, but I fancy few will be prepared to complain of the armament of the ships I have named who take kindly to the estimate of the relative importance of end-on fire embodied in them. But on the other hand, I am very well convinced of this, that if, in the immediate future, actual war should teach us that the relative value of the end-on fire is much less than it is credited with being in the most recent ships, neither we nor the country will spare the constructors who designed them, and they unfortunately will have little or no proof that they only did as naval opinion commanded them.

15. Thus, in brief, we see that a vast change in the method of arming our ships has come about in silent steps, and we are assumed to have come to very distinct decisions, when in reality—always excepting Admiral Randolph—we have only suffered an opinion to grow, and have passed it on, without any serious examination.

16. Let us take a concise survey of some of the broader considerations affecting this question. In such a ship as the "Alexandra," your endeavour must be to keep your enemy somewhere before the beam, where you can get your 25-ton gun to bear with four 18-ton guns. In such a position only one 18-ton gun will be out of action. Your enemy, on the other hand, will endeavour to keep a little abaft your beam if he is a simple broadside ship, because then the whole of his power will be opposed to less than two-thirds of the "Alexandra's." What means has the "Alexandra" for keeping her enemy before the beam, when the enemy is determined to remain abaft the beam? If the "Alexandra" has the greater speed, and uses it, she will but facilitate the wish of her enemy. If, on the contrary, she either has less speed, or uses less speed, her enemy can at once meet her by using still less. It is true that if the "Alexandra" can so arrange

matters as to get astern or on the quarter of her adversary at a small distance, the adversary must keep her speed if she has it, otherwise she will be ultimately and easily rammed in the stern, being the most tender point. The adversary will also, in such a case, find a great difficulty in getting out of that bow-position once she is in it, unless she has the superior speed. But this is only when the distance apart is small. If she is not at the moment afraid of the ram she can easily and at once alter her relative position to the "Alexandra." Thus we see that the position of an enemy subject to the most effective fire of the "Alexandra," must either be temporary, or else the gun-power which the "Alexandra" has been solicitous to employ, fades in value and convenience before her ram-power. If you have your enemy's stern or quarter ahead of you, and have the capacity to run into it, surely you will do so, and let your guns take their lower place? If, on the other hand, your speed is such that you cannot ram her, it is very certain that she will not stay there on either bow if she cannot make an effective reply from that position. But now take the converse case, where the adversary having got a position a couple of points abaft the "Alexandra's" beam, and finding her advantage from more than one-third of the "Alexandra's" gun-power being out of action, proposes to stay there and make use of her advantage, how is the "Alexandra" to shake her off? She dare not reduce speed, for that will bring her the adversary's ram; she dare not attempt to bring her guns out of action to bear; that also will lay her open to the ram. She may turn away from her adversary, but it is risky if the distance is small, and if not, her adversary will simply place herself on the opposite quarter and go on again.

17. Now consider a like case with an "Inflexible," as she is, opposed to another with her turrets in the middle line of the ship. The weak points in the "Inflexible" are four points before the port beam, and four points abaft the starboard beam. If the adversary can lie on either of those points she will have just double the power of the "Inflexible," and she will undoubtedly choose the starboard quarter for the reasons already given. The "Inflexible" in this case has an advantage over the "Alexandra," inasmuch as both her quarters are not equally weak: if she can only bring her opponent on her port quarter, the latter will lose her advantage. Under these conditions, it is quite certain that the adversary would not remain on the port quarter, and if she were unable to regain her true position on the starboard quarter we should either find her fighting it out on an equality on the port quarter, or yawing across and across the stern of the "Inflexible" so as to bring her after turret into play. If the "Alexandra's" battery were turned end for end, so that her strength lay abaft her beam, and her weakness before it, the adversary's nominal tactics would be to lie before the beam on either side; but this is clearly a position she could only maintain by favour. If the "Alexandra" had the superior speed she would drive her adversary off with her ram. If she had the inferior speed, she would bring him abaft her beam and subject him to her heaviest fire at her discretion.

18. If the "Alexandra" met a ship whose strength lay in stern and

quarter fire, just as the "Alexandra's" lies in bow fire, then the endeavour of each would supplement that of the other. The "Alexandra" would desire to keep her enemy on the bow, and subject to her heaviest fire, while the enemy would equally desire to keep the "Alexandra" on her quarter, and subject to *her* heaviest fire. But I do not think any naval Officer at present knows how the "Alexandra" can subject another ship to her heaviest fire if the other ship does not desire it. Certainly no one has yet shown how it is to be done. Even Admiral Randolph's paper confirms this view, for the only position at all approaching permanence which his ships take up, is where he assumes to force his enemy, by priority of his own movement, to lie on his quarter. He makes no attempt to force him to lie on his bow, because, no doubt, he has found it impossible to do so. But it is evident that he cannot really "force" his enemy to lie on his quarter. That is a question entirely in the hands of the enemy himself. It may be, perhaps, that the enemy must either lie there, or gradually discontinue the action. But this, as I have elsewhere endeavoured to point out, leaves the advantage on the side of the enemy. Admiral Randolph in such a case would have been driven off his own ground.

19. From this discussion we deduce the broad principle that in a duel in the open sea there is now but one position which can approach permanency, in which end-on fire comes into play, that is, where one ship desires to keep the other on her quarter, and the other desires to keep her enemy on the bow. I believe there are no two ships afloat which would mutually aim at these positions. No doubt these positions would be as good as any others for carrying on an artillery duel between two ships whose armaments were similarly disposed, but then the danger of the ram is so great that no ship which did not gain in gun-power by the act, would willingly allow an enemy to lie on her quarter.

20. Such broad considerations as these would lead us to suppose that the tactics of the duel—which is alone before us in this paper—would lead in the opposite direction to that at present taken in the design of our war ships; if it is in any case safe to withdraw guns from their ordinary broadside use, they should be withdrawn to strengthen the stern and quarter fire; the bow fire may be left weak.

21. The argument is somewhat close, and may therefore bear repeating. In strengthening your stern and quarter fire, you guard your weakest part from the ram attack; in strengthening your bow fire, you are but setting up a weak rivalry with your most powerful weapon—the ram. If nothing else shows it to us, Admiral Randolph's paper does so, that if the action is fought by passing and re-passing on opposite tacks, all end-on fire withdrawn from the broadside is a dead loss. He knows this so well that his whole aim is to avoid such an action. Then he shows that there is but one other form of action which has any permanency, that is where one ship leads and the other follows. But this can only be a permanent form where the bow is the strong point of one ship, either from the ram or the gun, and the stern of the other is the strong point from its gun-power. Only one

cause will make the quarterly or stern position at all permanent for a ship with weak bow fire, that is, the prospect of using her ram; but this very prospect is that which will prevent the other ships from assuming the bow position. The ship which has got into the quarterly position will assuredly keep it, however weak her bow fire may be, if she finds herself gaining on her adversary, and sees a chance of ramming. But if the ship ahead observes this gain upon her, it is quite certain that she will quit her bow position if she possibly can, even if she gives up the superiority of her fire astern. On the other hand, if the headmost ship finds herself with the superior speed and the superior stern fire, she will be desirous of maintaining that position; but then the sternmost ship will quit her place the very moment she finds her fire from thence relatively weak, and her speed inferior. It would be simply fatuous to remain there, with no prospect of ramming and an inferior gun-power. She will remain, as I said before, if her bow fire is equal to her adversary's stern fire, but then it is a question whether the adversary herself will care to maintain a position which gives her no advantage, but leaves her open to be rammed if a temporary accident happens to her engines. Thus, to repeat again the important axiom, if it is safe, and tactically proper, to withdraw any guns from the ordinary armoured broadside, they should be used to strengthen stern fire; but then such strengthening can only be useful as a last resource to guard against the case of attack from astern by a ship with superior speed and the ram. The question still remains, is it safe and tactically proper to weaken the broadside, seeing that this superior stern fire is only a last and not very firm resource, useful chiefly when escape from the ram by manœuvring is impossible?

22. These are broad principles, but are, I think, distinct enough to draw out some clear discussion with the materials I shall put before the meeting before I close. But I must now pass to some of the cases where the end-on fire idea has now its greatest triumphs. I mean the cases of the "Shannon," "Nelson," and "Northampton." I call these ships the greatest triumphs of the end-on fire idea, because they are so on the surface, and perhaps also at bottom; but if I rightly understand the idea of their design it embodies a middle ground; one not taken up by Admiral Randolph, and one which if taken up by me would not have been carried out as it has been in those ships. It is very remarkable that Admiral Randolph, when he came to face the problem of the duel so boldly as he has done, gave up the stronghold of the end-on fire idea without a struggle. If any doctrine can be said to be distinctly held by the majority of the naval tacticians whose opinions have built our modern ships, it has been the importance of bow-fire during the approach of enemies' ships. The bow-to-bow action has been the only action contemplated by the majority until Admiral Randolph practically abandoned it. Where is it gone to, when the action is not held to begin until the ships are within 800 yards of each other? But the Admiral was compelled to abandon it, I have not the slightest doubt, and I consider that the logic of facts is every day converting naval men from that most mistaken view of a sea-fight, and teaching them that, during the approach, gun-fire is

neither here nor there even from an "Alexandra." But in the "Shannon," "Nelson," and "Northampton" the heaviest guns are withdrawn from the ordinary broadside, and in the "Shannon" there is no stern fire to correspond. In all three ships the armour is withdrawn from the broadside, and in the "Shannon" protects her from raking fire from ahead only. Here it is certain the importance of the position of approach is upheld almost to an extreme point. How, therefore, shall we fight these ships, having demanded them and obtained them? Clearly, during the approach, we are expected to use and rely on our 18-ton guns forward. Clearly also we are to pass our enemy on opposite tacks with electric broadsides ready and with the men below. But now look at the tactical assumption we are making in reference to this bow 18-ton gun. If we withdraw it from the intended broadside at close quarters we are assuming that it is more effective when fired at long range end-on than when fired at short range broadside-on. If we determine to make it a part of our projected electric broadside, then we must be content not to use it as an end-on gun within say 800 yards. If we use it within that distance we must, at moderate speeds, be content to leave it out of the broadside, as it will not be ready in time.[1] Recollecting the shortness of the period of approach, I conceive that very few naval Officers would hesitate as to the proper employment of this gun under such circumstances. A round at 1,600 yards and another at 800 yards, with a very great risk of not getting a third at all, would, I feel certain, decide any Captain in command of one of these ships against employing the gun in any way during the approach, and in favour of treating it as part of his broadside. But then, in providing him with this end-on fire, which he is so unlikely to use unless the circumstances are exceptional, we have not inconsiderably detracted from the value of his broadside. To bring every gun to bear, they must all be laid right abeam, and seeing that any complete concentration is difficult even on this point, there is a very great chance of only a portion of the broadside taking effect. If in the "Nelson" the whole six guns were free to concentrate on a point 200 yards distant, the electric broadside would naturally be discharged the instant the enemy's bow appeared in the cross wires of the director. This would ensure hitting even if there was a hang fire. But if there were no concentration it would hardly be prudent to fire until the bow was well past the cross wires. A too early fire might lose shot ahead, and a too late fire might lose shot astern of the enemy's ship. In this kind of action the stern 18-ton gun would in the same way be most usefully embodied as part of the broadside, any shot fired later from it would clearly be of less value, beside the consideration that, if it did not go with the broadside, the smoke from the latter might prevent a shot being got at all at a reasonable distance.

23. Those who go fully with Admiral Randolph in the objections to electric firing would no doubt fight the "Shannon," "Nelson," and

[1] At 20 knots mutual approach, 800 yards = 1′ 12″; average time between rounds with the 18-ton gun 1′ 11¼″. See Noel, "Essay on Great Britain's Maritime "Power." Journal, vol. xxii, p. 464.

"Northampton" as just described, except that the captains of the guns would remain, tube-lanyard in hand, and await the order "fire" by word of mouth. But if they go still further, and condemn firing by broadsides altogether, then I am afraid they must condemn the three ships in question, for as against armoured ships of their size they may be weak. Suppose the "Nelson" pitted against a ship like the "Bellerophon," and suppose the "Nelson," rejecting the opposite tack and broadside action, takes one of Admiral Randolph's positions to bring the "Bellerophon" on her starboard quarter. Then suppose the "Bellerophon," seeing certain advantages in this position, accepts it, provided she can keep sufficiently up to bring her port broadside to bear by a slight yaw. Then we can see what will happen. She will have opposed to her one 18-ton and four 12-ton guns, but the four 12-ton guns and their crews are unprotected by armour. Every one of the "Bellerophon's" shells striking this unarmoured part will not only be horribly destructive where it strikes, but will be partly in the nature of an enfilading shot, and will create havoc along and on both sides of the deck. The "Bellerophon" will reply with five 12-ton and one $6\frac{1}{2}$-ton gun. But these are all under armour. In absolute gun-power the "Bellerophon" is only inferior, if one 12-ton and one $6\frac{1}{2}$-ton gun are inferior to an 18-ton gun. In relative gun-power she will vary according to her position, that is, according to the angle at which the "Nelson's" shot will impinge on her plating. The "Bellerophon" would endeavour not to engage too closely, and would take care not to expose too much of her broadside target to guns which would easily pierce her 6-inch plating. I suppose her choice position would be 500 yards, and three or four points on her enemy's quarter. Under such conditions she would be pretty safe from the 12-ton guns.[1] At the moment of firing her broadside she would be more open to hurt, but we are to suppose that she would so time her broadsides as not to open her target until after the "Nelson" had fired, and before she was again ready. Under such conditions the *relative* gun-power of the "Bellerophon" with the "Nelson" would be five 12-ton and one $6\frac{1}{2}$-ton guns against a single 18-ton gun, and I should imagine that the superiority would be so great that the "Nelson's" crew would be unable to stand to their guns for any time. But this is a problem requiring special and close working out. It is quite true that a shot from the 18-ton gun would penetrate the "Bellerophon," but then several shot would strike the vulnerable battery of the "Nelson" for one which struck a vital part of the "Bellerophon," and the balance would seem to be very much indeed in favour of the latter ship. It may be said of those who reject the opposite tack system of fighting that the "Nelson" could destroy the "Bellerophon" by keeping her astern and using her protected 18-ton guns only. But I think the "Bellerophon" would not accept this kind of combat, and I do not know how the other would compel her. It may be said again that the superior speed of the "Nelson" would give her the choice of positions with a "Bel-

[1] Roughly speaking, her target as opposed to the 12-ton guns would be $8\frac{1}{2}$-inch plate, 14-inch backing, and 2-inch skin. A target representing perhaps 117 in resisting power against the 12-ton shots, with 109 of energy per inch of circumference.

"lerophon." It would give her, I think, the choice of bringing her to action, and if the "Bellerophon" was not very careful it might give the "Nelson" the chance of the ram from astern, but there appears to be only one position which superior speed can command, that is the position ahead or on the bow of the adversary, and then we have seen that the other ship need not accept the rear position if she does not wish to do it. I think the argument goes to show that to fight with an advantage over an armoured broadside ship of their sizes, the "Shannon," "Nelson," and "Northampton" must adopt the opposite tack principle, and this is a principle which the other ships, being of inferior speed, must either accept or fly from, with the chance of being ultimately rammed from astern. But if these ships are to be fought so, then I conceive that there are very grave doubts as to the value of their special end-on arrangements. Their battery armour is disposed as though their chief danger was raking fire. Their heaviest guns are placed as if this offering of themselves to raking fire were to be the normal position of the ships in action, but it looks as though they could only take up such a position either at a great loss on the bow of the enemy, or astern of the enemy, when their presumed superior speed and consequent chance of ramming throws the whole gun question into the background.

24. I have brought these practical considerations before my brother Officers in order to at once disabuse their minds of a too prevalent view that the matter Admiral Randolph debated is speculative. There is at this moment no question which is less speculative and of more immediate application. If a strong gathering of leading naval Officers in this theatre came to a perfectly clear judgment on the relative importance of bow and end-on fire in a naval duel in the open sea, and if it could be shown that their conclusion rested on a definite basis of fact, there is not a draughtsman at the Admiralty who would not only be bound, but would feel himself bound, by that decision. It is quite certain that no clear decision has yet been arrived at, and that our ironclad ships represent every view, from nearly all end-on fire to no end-on fire. As every opinion cannot be right, some embodiments of these opinions must be wrong. The very practical question before us is, which?

25. It may be argued that no decision is possible, and that we must go on arming our ships haphazard according to the unstable opinion of the day. I do not think that anyone who holds that opinion has mentally faced its consequences. Suppose that the wrongly-armed ship on our side gets opposite the rightly-armed ship on some other side, will the passions roused in England by the result admit of a calm debate such as we can have now? No; this is the real time to debate such questions, and Admiral Randolph has shown us how to do it.

26. But to come to definite conclusions, we must submit to more restrictive conditions, than those the Admiral employs. When, under these restrictive conditions, we get conclusions which are approximately true, and cannot be controverted with any show of reason, then we enlarge our conditions by the variation of one of them, and on this we advance to further conclusions, and so on, until we establish the truth

so far as it can be established. Then, all who listened to the Admiral's papers must have become aware that no single mind was capable of establishing conclusions. They were only to be arrived at by the contest of two minds, one taking up one idea of fighting a naval duel, and the other a different idea. Then, upon the application of the fixed conditions, each combatant will learn how much of his idea is tenable, because the upholder of the other idea will find out its weak points. I venture to propose to the meeting that the discussion should take the form of arguing out some principles of the naval duel under these fixed conditions, and I have prepared the necessary materials. I will myself, assisted by any members who think with me, take up and fight a broadside ship, while I propose that some other member who relies much upon the end-on method, assisted by such as agree with him, should take up a ship armed to represent an *equality* in the importance of broadside and end-on fire. I have already shown you that our modern ships have assumed a much higher value for end-on fire, and our older ships a much lower value; to take them as equal, will therefore be a fair starting point.

27. I invite you in short to play the first naval war game which has ever been played in public in England, and the conditions and instruments of the game may be shortly described. We have first a sheet of paper representing a portion of the open sea. Two hostile ships, X and Y, have sighted and approached each other until they are end-on and distant 2,000 yards. Each ship is of like size and construction; each has the same thickness of plating and the same number of guns of identical power. The guns are in battery, not in turrets or *en barbette*. They are eight in number in each ship, and X, representing a pure broadside ship, has her guns in broadside ports, allowing of three points training before and abaft her beam. The ship Y, relying equally on broadside and on end-on fire, has her guns disposed with two on each broadside, two representing bow fire, and two representing stern fire; that is, two guns will train three points before and abaft her beam. One will fire from right ahead to two points before each beam; and one will fire from right astern to two points abaft each beam.[1] These guns are all under the single condition, that one minute of time shall elapse between each discharge.[2]

28. In motive power, our ships can each have a speed of 8·2 knots or of 10·4 knots, or one may have the higher speed and the other the lower. I impose the condition, however, that neither ship shall alter her speed during the fight.[3] I also think that, at this first public trial, we should keep the speeds equal, and so simplify the conditions.

29. In turning powers, the ships are necessarily limited by their

[1] In the modern battery ships, the tactical value of the end-on guns is in most cases increased by enlarging the arc of training to 90°. I have a right to claim either its reduction as above or the same arc for broadside guns.

[2] This is Admiral Randolph's condition: the 18-ton gun averages 1′ 11¼″ between each round in prize firing, the 12-ton gun 39¼″. These times would certainly be increased in action. See Noel, "Naval Essay," 1877.

[3] This is one of the conditions which may hereafter be enlarged upon definite data.

speeds. But I am prepared with scales which suit either speed. These scales show the time and space occupied in turning through any number of points up to 8, or beyond that turn. These scales also show the spaces traversed on a straight curve per minute, and they also contain a scale of yards, and a means of measuring compass bearings and arcs of training for gun-fire. In employing these scales, I impose the condition on each ship, that she shall put her helm hard over when she moves it at all.[1]

30. The scales are drawn from the most accurate data available. They represent very nearly the absolute truth as regards Her Majesty's ship "Thunderer" in smooth water. And if we suppose our batteries mounted on the under-water hulls of two "Thunderers," we are dealing with conditions of speed and turning powers which are only in a very small degree hypothetical.[2]

31. Each ship is a ram, and at liberty to use the weapon, but, of course, equally open to be rammed herself.

32. It is necessary to impose conditions of time upon the combatants, and these conditions are that so long as the distances are so great as to preclude the direct delivery of the ram blow—whatever the ultimate intentions may be—each combatant has a move extending over one minute of time. When the delivery of the ram blow is announced, the move lasts for half a minute. It is further allowed that each combatant may, when his turn comes to move, control his ship up to the end of two moves; that is, while his adversary is moving, so that he can take his ship up again where he intended she should be.

33. A successful ram will of necessity decide the combat. Otherwise the winner will be decided by the value of the shot fired. These values can be taken out from the Table, the construction of which can be briefly explained, and is a very fit subject for discussion at the end. Two elements clearly govern the probable value of shot fired, the distance of the target, and the angle at which the shot would strike. A third element comes in for ships in the size of the targets vertical and horizontal, which vary according to the angles the path of the shot makes with the line of keel. For end-on shot, the horizontal target is at its maximum, and the vertical target at its minimum and *vice versâ* for broadside shot. As, with our present data, any table of this kind must be somewhat empirical and rough, I allow these two values to eliminate each other. Then I say that the maximum value of a shot fired at a ship must be when there

[1] This is also one of the conditions capable of enlargement when reliable data come before us. At present there is very little of a reliable character.

[2] Admiral Randolph has supposed the "Thunderer" to be an exceptional ship in turning powers; but this is not so. The diameter of her final circle, at 11 knots, is 4·3 lengths. That of the "Iron Duke," with common rudder and ordinary wheel, is 5·4 lengths at full speed. The other ships of her class, with balanced rudders and common wheels, have a final diameter of 3·8 lengths. The "Thunderer," at 11·1 knots, turns through 16 points in 2′ 21″. The "Iron Duke," at full speed, turns 16 points in 2′ 26″, and the other three ships of her class in 2′ 8″. Five French twin screws are stated to average a final diameter of 5·28 lengths, but there are doubts as to the measurements.

is almost a certainty of hitting, and the shot if it hits will strike fairly normal to the armour. I put this as giving a distance not exceeding 300 yards and a path of shot at right angles to the line of keel. If the shot is fired along the line of keel, I strike off 20 per cent. of this value as an allowance for the angle of the water-line plating, and for the chances of the light iron work turning the missile before it reaches the thwart-ship armour. Now, the chances of hitting a given vertical target must vary at least as the square of the distance. The power of penetrating also falls rapidly with the distance. If I reduce the value of shot fired at the broadside and end-on targets in proportion to the square of the distance, it would appear that I am giving the full value which distant fire can claim. There remains now, but to find a value for each distance for shot fired in a direction between 0° and 90° to the line of keel. This is done by considering that at 4 points from the line of keel, shot falling on the broadside and transverse plating would be equal in penetrating power, but reduced in value in consequence of their striking angle. Roughly taking such loss as one half of the maximum, we fill the columns up by interpolation.

34. I am now in the hands of the Chairman and of the meeting as to the form of the discussion. I have given the principles of my War Game, which I hope will very soon be published in a workable form, but if we play the first public game as I propose, I must remind the meeting that no single game will decide this question of placing the guns. All I am prepared to express is my belief that we are getting a key to construction and armament, which will have from this day forward a very direct and important bearing on naval policy all over the world.

35. The exact problem which I offer for investigation to-day is, can the ship X, by skill in manœuvring, employ half his gun-power over an arc extending three points before and abaft his beam, with success against a ship whose skill in manœuvring is less important because there is no point uncovered by his gun-fire, and whose only disadvantage is that in the position in which X will aim at placing him he has only three-eighths of his full strength?

36. It will have been observed that there is very little originality in my proposed methods, and that mine is not the first attempt at a War Game. I have already expressed my obligations to Admiral Randolph; I must now express them to Commander Castle, who made the first definite proposals for a War Game in 1873, and who first devised the construction of scales representing time and space in movement. I am doing little more than following where others have led, with the assistance of newer data.

Table for Valuing Shot Fired.

Distance in yards.	Striking Angle in Points.								
	0	1	2	3	4	5	6	7	8
300	80	70	60	50	50	50	60	80	100
400	45	38	33	27	27	27	33	45	55
500	29	26	22	18	18	18	22	29	37
600	20	17	15	12	12	12	15	20	25
700	15	13	11	9	9	9	11	15	19
800	11	10	8	7	7	7	8	11	14
900	9	8	7	6	6	6	7	9	11
1,000	7	6	6	5	5	5	6	7	9
1,200	5	4	4	3	3	3	4	5	6
1,400	3	3	2	2	2	2	2	3	4
1,600	3	2	2	2	2	2	2	3	3
1,800	2	2	1	1	1	1	2	2	2
2,000	1	1	0	0	0	0	1	1	1

The CHAIRMAN: It seems to me that Captain Colomb in his very interesting paper invites us to do two things: one to discuss the various suggestions he has thrown out, and the other to witness a war game this evening which he has sketched out and shadowed forth to us. The discussion is a very simple matter and will not involve any difficulty, but the war game is a very different matter; who is to be the umpire? If Captain Colomb is prepared to step down in the arena and to conduct a war game with some one else, it is necessary of course to have an umpire who thoroughly understands the game, its rules, and the whole subject, and from whose decision there is to be no appeal. Now as far as I know there is no one present to undertake that post to-day, and therefore I should be inclined to advise you to hear the discussion, and defer the war game until a future occasion. I will now call upon any gentleman who wishes to discuss the paper.

Admiral RANDOLPH: As our gallant and talented lecturer has done me the honour of making my paper the text for a large part of his paper to-day, perhaps you will permit me to make some observations upon it. First I would wish to pay him my tribute of praise, admiration, and thanks for the painstaking and thorough-going manner in which he has investigated and elucidated this very important subject, a subject second to none of the very many important ones which are the necessary studies of our profession. I said "second to none," but should I not be more correct in saying superior to all? for I believe all your material put together without good naval tactics will be absolutely worthless. Notwithstanding this, I am sorry to say I feel that although it is so important a subject it is precisely the one that is least attended to and practised of any, and certainly not through any want of zeal or fault of the Officers themselves. I hold that at the present day naval Officers, as a

body, hunger and thirst after knowledge and practice, to a degree utterly unequalled at any former period: I impute no blame or fault to anybody. At the Admiralty no doubt every possible attention is paid to this question of naval tactics, more especially perhaps in reference to its connection with naval construction. No doubt they have their discussions, arguments, and reasonings, and arrive at sound conclusions, but unfortunately we are unable to obtain those conclusions. Of course it is impossible for them to make them public, and therefore I see no better means of introducing the subject generally to the notice of the profession, of enforcing the discussion, of investigating it, and, if possible (and I believe it to be possible), arriving at some rules which unquestionably underlie the service of naval tactics. It is for this reason I have overcome my very great reluctance to obtrude my own crude and erroneous notions upon the Institution; but I came to the conclusion to invite their contradiction or overthrow, with a view to promote the discussion of this great subject, and the gallant lecturer has done me only justice in stating that that was my object, and that I did not pretend to dispose of the subject. With these few preliminary observations, I will turn to the paper which he has read.

In the first place I beg to express my great acknowledgments to the lecturer for his extreme, he will pardon me for saying so, more than courtesy, the undue compliment which he has been kind enough to pay me. He has stated in some part of his paper that I abandoned the struggle, or some portion of the struggle. I assure him so long as he is willing to maintain the struggle in the amiable and pleasant manner in which he has conducted it hitherto, and so long as he wears such soft gloves, I shall be happy to continue it. In the first place he says "the differences of "opinion which exist amongst us on the rights and wrongs of naval tactics are "removable in peace time by study and experiment." I certainly agree with him to a very great extent there, and so far as they are removable it is very desirable to attend to it.

Although he has done me more than justice in many respects, he has failed to do me quite sufficient in some few points. He says: "I found in short—or perhaps I "should say I thought I found—that all the results arrived at by the Admiral were "not supported by a still closer investigation, and a still more rigid adherence to "ascertained facts." I have no complaint to make of that, but I think I shall be within reason in asking him to point out to me wherein those facts are unsupported and wrong because he gives me no opportunity of meeting them or correcting them. In paragraph 16 he enters into the question of the "Alexandra." I cannot be expected to follow him through that at present; it requires a great deal of consideration, and I have no doubt it will result in finding a great deal of instruction from it. So far as I observe I see nothing to complain of. He says the "Alexandra" "dare not "reduce speed, for that will bring her the adversary's ram; she dare not attempt to "bring her guns out of action to bear; that also will lay her open to the ram. She "may turn away from her adversary, but it is risky if the distance is small, and if "not, her adversary will simply place himself on the opposite quarter and go on "again." I thought the principle of our argument was an equality in all respects except armament, and therefore of speed, therefore I fail to see how the "Alexandra" can lay herself open to ram by turning away from her enemy. The lecturer says: "I do not think any naval Officer at present knows how the 'Alexandra' can subject "another ship to her heaviest fire if the other ship does not desire it. Certainly no "one has yet shown how it is to be done. Even Admiral Randolph's paper confirms "this view, for the only position at all approaching permanence which his ships "take up, is where he assumes to force his enemy, by priority of his own movement, "to lie on his quarter." I wish to ask where that assumption is made in my paper. I should explain that that is a mistaken view, and indeed I think our gallant lecturer contradicts himself. He goes on to say, "he makes no attempt to force him "to lie on his bow, because, no doubt, he has found it impossible to do so." I think that is rather contradictory. "But it is evident that he cannot really 'force' "his enemy to lie on his quarter." Certainly I have never assumed that it was possible. "That is a question entirely in the hands of the enemy himself." Then he goes on to say, "but this, as I have elsewhere endeavoured to point out, leaves "the advantage on the side of the enemy. Admiral Randolph in such a case would "have been driven off his own ground." I cannot quite see how. "The argument

"is somewhat close, and may therefore bear repeating. In strengthening your stern "and quarter fire, you guard your weakest part from the ram attack; in strengthening your bow fire, you are but setting up a weak rivalry against your most "powerful weapon—the ram." I am at a loss to understand how heavy and powerful bow fire sets up a rivalry against your own ram. It rather adds to the force of the ram attack. "The ship which has got into the quarterly position will assuredly "keep it, however weak her bow fire may be, if she finds herself gaining on her "adversary and sees a chance of ramming. But if the ship ahead observes this "gain upon her, it is quite certain she will quit her bow position if she possibly can, "even if she gives up the superiority of her fire astern." But this gain upon her is exactly contrary to the equality which has been assumed.

Captain Colomb: All through the paper I have been discussing differences of speed.

Admiral Randolph: Then, "on the other hand, if the headmost ship finds herself "with the superior speed and the superior stern fire, she will be desirous of maintaining that position; but then the sternmost ship will quit her place the very moment "she finds her fire from thence relatively weak, and her speed inferior." That is open to the same observation. Further on I find a question about the "Shannon," "Nelson," and "Northampton." "I call these ships the greatest triumphs of the "end-on fire idea, because they are so on the surface, and perhaps also at bottom; "but if I rightly understand the idea of their design, it embodies a middle "ground; one not taken up by Admiral Randolph, and one which, if "taken up by me, would not have been carried out as it has been in those "ships." I think he has rather made an unfair rivalry between two ships, one being an ironclad and the other not; he has pitted the "Nelson" and "Northampton" against the "Bellerophon," a ship such as I believe they were never intended to compete with. "Those who go fully with Admiral Randolph in the objections to electric "firing would no doubt fight the 'Shannon, 'Nelson,' and 'Northampton' as just "described, except that the captains of the guns would remain, tube-lanyard in hand, "and await the order 'fire,' by word of mouth. But if they go still further, and "condemn firing by broadside altogether, then I am afraid they must condemn the "three ships in question, for, as against armoured ships of their size, they may be "weak." The next thing is, "If a strong gathering of leading naval Officers in "this theatre came to a perfectly clear judgment on the relative importance of bow "and end-on fire in a naval duel in the open sea, and if it could be shown that their "conclusion rested on a definite basis of fact, there is not a draughtsman at the "Admiralty who would not only be bound, but would feel himself bound, by that "decision." On that question I wish to remark that when we have arrived at a determination as to this question between two rival ships, supposing we arrive at a unanimous conclusion upon the subject, we are still very far from the position that paragraph alludes to; there would still remain the question as to various other phases of naval fights. For example, ships in squadron, or engaged with a numerous enemy, which opens the question of numbers of guns. Then again, a ship against unarmoured ships or earth batteries, involving the consideration of continuous rapid firing, as well as numbers of guns; or against ships at anchor, or inside shallows, when long range is of most importance or indispensable. In short, I think we shall ultimately be forced to the conclusion that there is no one type of ship which can be considered the modern and perfect type. The Navy of England must be composed of various types, to be combined in various proportions and various numbers, according to the operations in prospect, according to the force, number, and position of our enemy, and the varying conditions and operations of the moment.

On the subject of the war game, I do not accept that vessel (sketched on a slate) as a necessary embodiment of the principle of equal number of guns with end-on fire. I do not think there is any ship in the English service that represents the idea, unless it be the "Inflexible," of equal stern and bow fire. If you confined me to four guns fore and aft, I should certainly put three ahead and one astern. Captain Colomb has omitted to take into consideration the very certain fact that fore and aft guns can be and are carried much heavier than broadside guns, and it is impossible for him on his broadside to carry, if any, very few equal in calibre to those which are constantly carried in fore and aft fire. But when the combination of ships is effected,

which I say is absolutely necessary, with the greatest amount of discretion and foresight for an impending operation of war, after all it would be perfectly futile unless those ships are well handled; I am persuaded that if you sent the "Alexandra" and "Téméraire" to fight it out at sea, the victory would be, not to the strongest in material power, but to the one best handled. I must say, therefore, I wish to draw the attention of the meeting and the profession generally to the extreme importance of this point of practical skill in tactics. I think under many circumstances ships being fairly well handled might suffice, but in the circumstance of meeting at sea, you should not be content with equality with other nations, but we should go in for superiority. I do not think we are taking steps to attain that superiority. If I am correctly informed, foreign nations are paying much more attention to this subject than we are, and I think a great lesson can be drawn from those simple manœuvres practised in Russia some time ago, for which this Institution is greatly indebted to our gallant Chairman. Those diagrams may not have struck many as very instructive, but I think they are, for if they do not give any positive information or instruction as to what are the proper methods of attack, they certainly give a great deal of negative information as to what are not in defence. Of those collisions, six or seven in number, all except one, and that one only doubtful, are clearly traceable, not to the superior skill of the successful vessel, but to the palpable and transparent errors of the victim. Far be it from me to insinuate that our ships are not as efficiently commanded as we could desire. As far as I know they are most ably and admirably commanded—speaking from my own experience, excellently commanded. But I cannot but fear that there are a large number of Officers on the list who have not had that practice and experience at sea, and who would be found deficient and failing in proficiency if they were called upon to serve. I therefore feel the greatest possible anxiety that further steps should be taken towards the establishment of a systematic method of training our younger Officers in the practical work of handling their ships at sea. I do not think it is necessary to expend any great amount of money. The gunboat trials in the Russian squadron are full of information; a vast deal of information is got out of a very little experience in that way, and it could easily be carried a little further than steam launches and gun boats by larger vessels who need not ram each other, but spars or rafts towed astern. I hope to live to see the day when the profession will be trained under a system, and so thoroughly, that we shall incur no danger of losing our position in the naval world. I thank Captain Colomb for his admirable lecture, and for his extreme courtesy to myself personally.

Captain LONG: I rise with great diffidence before this distinguished audience, but I wish to bring to a clear issue one point in which Captain Colomb, who has taken as much if not more trouble about these subjects than any other Officer of the Navy, and Admiral Bourgois, of the French Navy, hold diametrically opposite opinions. Captain Colomb says, if you want to ram you must not point your bow to your enemy. Admiral Bourgois says, "The first conclusion to be drawn from "these studies is that should one of two adversaries desire to fight a ramming action, "it is sufficient to compel both to rush at each other and rub sides on opposite "tacks." Captain Colomb has said, "if we collide end-on it is a drawn battle," but Admiral Bourgois says, "you must collide end-on to begin with, if you wish to fight a "successful action. After that you must turn according to your powers, and endeavour "to ram the other, but if you are a ram, the first thing you have to do is to ram end-"on." I hope something will be said to clear up that point.

Admiral Sir GEORGE ELLIOT: I wish to a certain extent to support the French Admiral's views which have just been quoted by the last speaker, but in the first place I desire to join with Admiral Randolph heartily in my thanks to Captain Colomb for the interesting paper he has just read. I hope he will persevere. I think we owe him a debt of gratitude for the trouble he has taken. It is well enough to talk about these things, but it is a very difficult thing to bring them actually to an issue, as he has done. He knows, however, that I take rather different views from him on this subject, and I am sure he will excuse me if I refer to some parts of his lecture on which we disagree. In the first place he refers solely to guns, and does not take cognisance of the cognate question of the use of armour. That question of placing the armour is most important. I am a very strong advocate of end-on fire and end-on attack. I cannot go so far as the French Admiral in saying

that two ships *must* begin by meeting end-on, because I consider that the ship which has the weaker bow must necessarily avoid meeting his adversary's end-on attack. If a ship is a broadside ship she must have the weaker bow. I may be wrong, but that is my argument. If she is a broadside ship, she must necessarily have more of her armour, that is more of her strength, in midships, and therefore she must have the weaker bow. And when I say I fight an end-on fight, I must be allowed to take the same weight of guns as my enemy, and the same weight of armour as my enemy, and do what I like with them. I am not to be bound (as Captain Colomb proposes) to put my armour in midships and my guns pointing to the bow and stern, but I take my armour and put it where I like, and how I like, and mount my guns as I like. One of the first considerations in constructing a ship intended to ram should be to strengthen the bow, because if I did so, and if I had any reason to believe that my enemy was a broadside ship, I should conclude he must have his armour to protect the broadside guns in midships, and that his bow must be comparatively weaker than mine, and that knowledge would greatly influence my mode of attack. To show what I mean, there were two ships lying end-on alongside the Dockyard at Portsmouth, one the "Dreadnought," and the other the "Inflexible." Out of curiosity I put a question to an experienced old Officer who was in charge of the "Dreadnought," which ship's armour-plating came right forward, that is to say, that there was an armour water-line belt meeting at the bow. I said, "Suppose these "two ships were ramming each other, bow to bow, at a speed of 10 or 12 knots, "what would be the consequence?" "Well," he said, "I do not suppose I should "bring up in the 'Dreadnought' until I came to the central citadel of the 'In-"'flexible.'" I quite agreed that the "Inflexible," having a weak bow, there would be nothing to stop a stouter bowed ship from destroying her in the event of end-on collision. But the other ship having armour-plating right forward, and being a stiffer ship, would not break up at all. In fact, if you take two eggs and strike one with the other, if the one is in the slightest degree stronger than the other, it will go right into the other, and will not break at all. The same with the ship; whichever has the stronger bow will destroy the other. Therefore, when I adopt end-on tactics I say you must allow me to place my armour and my guns as I like, the same weight as you have, but I must place them where I like. Therefore in a ship constructed for end-on fighting I would decidedly run at the other ship, and as the broadside ship dare not run at me she must turn away from me. I do not believe I shall be denied that. If she dare not run at me, she must turn away at a sufficient distance to avoid being rammed. But, my object still being to keep an end-on position, directly I see my adversary move, I turn towards him, steer at him full speed, and continue the same tactics. Whatever he does, I go straight at him. He may discharge one or two broadsides at my armour-plated bow, which is well protected, and in return my bow guns will continue firing on him; but he must soon commence a running fight, and then what becomes of him? He has no stern guns and no armour protection astern, but still I am firing my bow guns at him, and I have a protected bow. I have my bow strengthened by horizontal decks, and in every way made as stiff as possible, having applied a certain portion of the weight of armour for that purpose. The consequence is he turns away and I follow him. I ask at what distance will he turn away? He would not turn away out of gunshot range; if he does he runs away. You may say he runs away and gets away, but that is not fighting. The moment he turns away within gunshot range I turn towards him. The end of it must be that I come on his quarter at last. Now I say if I once get on his quarter within a certain distance that ship ought to be mine. His stern is in every respect more vulnerable than my bow, and there is nothing to protect his screws or his rudder from my bow fire. If he is out of range of fire he runs away, and both having equal speed, there the action will end. You talk of making circles, but if my sole object is to close, if I once get on his quarter within a certain distance my adversary never can turn round again. He dare not show me his broadside; let him do it. The moment I see him turn I have a shorter distance to go. Every time he attempts to turn I take the inner circle and get nearer and nearer to him, and the consequence is he will have to fight that battle out, running away the whole time, and that is all he can do. If my bow is stronger than his stern I ought to win; therefore I do not agree with Captain Colomb in some of his remarks where he said

two ships must avoid end-on meeting. I would not avoid it, I would invite it, if I in my ship met his ship.

Captain Colomb: I did not say that. I have said in the war game that the end-on, stem-to-stem meeting necessarily makes a drawn game: that is all I have said, no more.

Admiral Elliot: Then I do not agree with that. It is not a drawn game if I destroy the other ship, which I maintain I can do if I have the strongest bow, and the whole of my argument is based on the assumption that you must let me put my armour where I like. If I take the guns from the midships and put them at the bow I place some armour there also, and therefore I have the stronger bow. I think Captain Colomb has shown that we are gradually growing into end-on fire. I look upon the "Nelson" and "Northampton" as the two best masted ships we have, although they do not represent my ideas of placing guns and armour, still it is an approach to the end-on principle. I think before we start with the war game the question I have just referred to should be at once settled—are we or are we not to be allowed to do what we like with the same weight of armour and guns? If you do not grant that, you at once deprive those who advocate end-on fire of one of their strongest points. I hope that Captain Colomb will be enabled to bring this matter to such a solution as will lead to instruction. I quite agree we all want to be educated on the subject of naval tactics, not only the young Officers of the Service, but the old ones. We have not turned our thoughts sufficiently to it; and even since Admiral Randolph's paper came out I am sure the consideration of it has done us all a great deal of good and has made us think of things we were sleeping over before. I hope it will not be allowed to drop, but will be carried out patiently till something is settled.[1]

Admiral Sir Spencer Robinson: Although there has been a very strong difference of opinion on certain matters, I concur very generally with much that has been said, and I wish to bring that agreement to bear upon the proposition that has been made. I am not going to discuss any of the matters on which there is a very wide difference of opinion, but what I should wish to say is that I think most of the objections taken would be answered and the greater part of the differences of opinion would be at once solved and laid aside if this war game could be established and played out. I would therefore propose to this meeting that one and all we should take every possible pains to get up a war game, to select an umpire, to lay down the rules, and so to have this war game played with the best abilities that can be obtained on the contending sides. I think it would not be quite possible to follow exactly the course that Admiral Elliot has suggested. It would answer no useful purpose to say that we would not try a war game nor acquire the knowledge and experience we might

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[1] The "end-on" ship I would propose is fully described in the dissentient report of the minority of the Committee of Designs for Ships of War entitled "Report of "Admiral George Elliot and Rear-Admiral A. P. Ryder on Designs for Ships of "War," which is dated October 14, 1871. After eight years of further experience I feel more convinced than ever of the correctness of the views entertained by Admiral Ryder and myself at that date, and I would invite the perusal of this report by those who take an interest in the problem of "end-on" versus broadside fire. The only alteration which I would now propose to make in the principles of designs advocated in 1871 would be that in lieu of the athwart-ship bulkhead I should place the armour round the bows especially at and below the water-line. I am pleased to know that the principle of water-line protection which we introduced in 1871 has been lately accepted as a desirable substitute for side-armour protection by the Chief Constructor of the Navy. I trust that this controversy of "end-on" versus broadside fire may result in also bringing into prominence the superior advantages to be obtained by mounting guns on revolving platforms *en barbette* within fixed towers on the upper deck, which feature will naturally lead to the adoption of tripod masts. It must be seen at once that all-round fire, if possible to be obtained in all ships, must be superior in every respect to any system of broadside battery fire, and the increased power of heavy ordnance has produced very grave objections to the continued use of revolving turrets.—G. E.

acquire by witnessing a combat on paper conducted in that way, because the particular ship that is to fight the broadside ship with advantage must be constructed in a way in which no ship has yet been constructed. I am afraid that to wait for such a plan would delay for a very considerable period any settlement of the question how a naval action in an ironclad should be conducted, or what is the relative value of broadside as compared with end-on armament. With that exception I think a great deal that Admiral Elliot has said is perfectly true. I concur with a good deal of what Admiral Randolph has said so far as the theory of the thing goes, and I think the differences of opinion that exist between him and Captain Colomb as to certain matters of fact and certain matters of deduction will only be solved by that battle upon paper. The point that I think is impossible for this Institution to take any part in at present, is in altering the construction of a ship so fundamentally as to have the armour and guns distributed in the way that Admiral Elliot would wish to have them put. I think we must fight a battle on paper in the same manner and with the same kind of ships as we should fight a battle in the open sea. There we should no doubt find ships armed on the end-on principle, and ships armed on the broadside principle in the manner Captain Colomb has pointed out, and the battle should be fought between two ships armed in those different ways. If that can be carried out I am certain we shall all derive the greatest possible advantage from the lecture we have heard and from those very valuable papers that Admiral Randolph has read to us.

Captain Cyprian Bridge: I am sure Captain Colomb will only be too glad if I point out to him one matter in which I think he has hardly done justice to one Officer. He opens his paper by saying: "To Admiral Randolph belongs the honour, "which, so far as I know, will be unchallenged, of being the only man in Europe "who has distinctly faced a tactical problem in naval warfare." I am firmly convinced no papers ever read in this theatre have been of such importance on the subject of tactics (the most important of all the questions that come before naval Officers), as those which Admiral Randolph read, but at the same time I think it ought to be remembered that some years ago one Officer of the English Navy did take up one particular tactical question and, in my opinion, and I think in that of others, did thoroughly exhaust it. That I believe to be the only instance. I have read most of the tactical literature of modern days and have studied a great part of it, and as far as I know there is no single case in which any Officer has taken up one particular tactical question and exhausted it in the same manner that Commander Grenfell took up what was then considered the very important question of the towing torpedo. It may be said Captain Colomb meant only when the different arms were all being considered, but it should be recollected, if that is the case, that there was at that time a very widespread opinion that this towing torpedo might to a great extent take the place of ships armed in any other way; we heard a great deal about tug boats and small steamers being equipped with this towing torpedo, and that the whole defence of the country might be left safely to them. Captain Grenfell took up this question, and I think thoroughly exhausted it. He showed exactly what might and might not be done by that particular weapon. Captain Colomb will not be sorry, if this is an omission, that I have pointed it out, and I am quite sure he would be the last man to do injustice to Captain Grenfell, of whose labours I have reason to know he has a very high opinion.

Dealing with the questions raised in the paper, I would go on to the 9th paragraph, in which the lecturer speaks of the series of ships, mentioning them by name, ordered from 1859 to 1863, and says: "We have only very faint indications of an opinion in "favour of end-on fire." I concur with him in thinking that opinion in favour of end-on fire since then has changed, and the reason I believe to be this: that at the period which he mentions, 1859, naval Officers (not naval constructors, probably, because I am sure even at this moment there can be few more magnificent instances of naval construction than the "Warrior" and "Black Prince"), that naval Officers were certainly under the influence of traditional feeling. All our previous battles had been fought with ships carrying long rows of guns on the broadside, and I do not think we had yet begun to realize how changed the conditions of naval warfare were, in seeing that ships retained their motive power probably throughout an engagement. Some years ago a French Officer in the *Revue des Deux*

Mondes pointed out the remarkable fact that although this retention of the motive power enabled the new ships to fight *de pointe* or end-on, we were still going on arming ironclads on the broadside, making them very much the same as the heavy frigates and line-of-battle ships of Nelson's days. There has been a change of opinion in this direction, and the armament of the newer ships gives a greater preponderance to end-on fire, using the word in its widest sense. I mean a capacity for firing towards the bow or stern. Suppose for the sake of argument we admit it was a mistake — which I am very far from admitting. Suppose we say, looking at it in the present state of our knowledge, that this taking of guns from the strict broadside position, and leaving them where they are, more or less in the end-on position, was a mistake. I think that at the same time the change that was made showed that the ships were being armed upon what at all events was something like a scientific principle, and we were not simply under the influence of the old traditional habit of custom, and of the designs of former ships. I had intended to have made some remarks upon the infinite variety of positions and circumstances of naval warfare, not only of naval warfare in general but even of particular actions between single ships, actions in squadrons, and actions where there might be a superiority of force on the one side or the other. But that ground has been altogether covered by Admiral Randolph, and as I should be quite unable to put forward any views on that point as well as he has done, I shall not attempt to do so. With respect to the war game on shore, I think I am right in saying a certain element of chance is allowed to intervene. I have never seen one, I have only heard it described, but I think that dice are used and a certain value is given to particular circumstances which may occur simply by throwing the dice. I do not know whether Captain Colomb thinks it necessary to introduce anything of the sort at present. Towards the end of his paper there is one paragraph which I think is very important indeed; it is a paragraph which says an immense deal, and says it because it does not put it very directly. He says: "The exact problem which I offer for investiga-" tion to-day is, can the ship X, by skill in manœuvring, employ half his gun-power " over an arc extending three points before and abaft his beam, with success against " a ship whose skill in manœuvring is less important because there is no point un-" covered by his gun-fire, and whose only disadvantage is that in the position in " which X will aim at placing him he has only one-quarter of his full strength?"

Captain COLOMB: That is a mistake; it ought to be "three-eighths of his full " strength."

Captain BRIDGE: I would end the sentence at the comma before that "no point " uncovered by his fire." I do not think it would be possible in so many words to say anything more strongly in favour of a ship armed as Y should be and more strongly against a ship armed as X should be; I think of all the criticisms that have been passed upon the paper that Admiral Randolph read, nothing in my opinion goes further to confirm the justice of the views that he expressed than is contained in that paragraph which I have just read.

Captain SCOTT, R.N.: The gradual development of bow and stern fire spoken of by Captain Colomb is no doubt correct, but I think that from the very first there has been a good deal of consideration given to the mode of arming ironclads. The "Enterprise," for instance, was armed for bow and stern fire, and the same system was aimed at throughout; but the means of mounting the guns so as to turn them round easily from port to port were then wanting, and a good deal of difficulty was experienced in supplying them. As these means became more and more perfect, the placing guns so as to be fought both upon the bow and upon the quarter, was more and more carried out. Many people considered it was *not* necessary to withdraw guns from the broadside to put them either at bow or stern, but that the guns should do the double duty, and in that view they were no doubt fully borne out by the results. There is no reason why these guns should not be turned by turntables, so as to be quickly brought to either position and fired. I do not think that the whole question can be fully embraced in a war game, limiting the combat to single ships; for our ships would sometimes have to fight in squadrons, at others they would have to advance up rivers, and likewise to cut out vessels. When acting in squadrons they would often not be able to use their broadside fire, and in moving up and down rivers they would frequently be unable to use broadside fire. Then there

is the question of the ship being aground and surrounded by gunboats. What chance would she have if she had merely broadside fire, especially if there were land batteries as well as gunboats playing upon her? What is required is to have each war ship armed with light guns, to play upon gunboats, and with heavy guns to attack powerful batteries, &c. There is the further point to be considered, which is, that our merchant vessels are not unlikely to be armed so as to play a prominent part in future warfare. A couple of such vessels would run an unarmoured ship very hard if she had only broadside fire; they would not allow her to use that fire, for they would follow her up closely, just as Admiral Elliot has pointed out in the case of a single combat; he has, I think, exhausted the arguments on that point. My own belief is, that our efforts should be directed to arranging all the heavy guns of a ship to fire from ahead to astern. There is no difficulty in doing this, it is merely carrying out a little further what has been already done in the case of the "Audacious" class. The guns could be mounted within circular projections,[1] so as to fire from all round the broadside to within 13° of the line of keel. This wide range of 154° on each broadside, with all the heavy guns on each side, is very important, for it leaves only 52° out of 360° which are not covered by the full broadside fire. Then, again, the ship is not always in smooth water, but you want, so far as you can, to keep the ship *steady* when firing her broadside. The circular projections would not only afford the power to do this, but you would be able (in consequence of the wide range of fire), whether advancing or retreating, to fire the whole of your guns, with a very slight alteration of course. Captain Colomb says he would yaw and fire his broadside; my experience has been that when you port the helm over the ship will heel, and you have wild firing, and if you attempted to fire while the ship was swinging, accuracy was very difficult of attainment. What is wanted is that the heavy guns should be able to command an arc of fire from ahead to astern, and I believe that future progress will be in the direction of placing light steel armour outside the guns, and giving the ship a steel deck, extending from the ram-bow to the stern, and throwing away the rest of the usual defensive armour. I think, however, it is very difficult to apportion the relative values of broadside and bow fire; both seem to me so necessary that, like the arms and legs of the human body, you cannot dissever one from the other without materially injuring the whole fighting power of the ship.

Mr. Scott Russell: One word only on a professional point, which must lead to a little confusion as to the mode of carrying on this matter. Admiral Elliot said he would like to take the armour away from the middle of the ship and place it on the end of the ship if the guns were carried there. I want to rid your minds of the supposition that the armour in the bow of the ship is of the least use to you in giving the ship the strength necessary to make her a better ship in the case of ramming. I am one of the few people who have taken the trouble to run down vessels, to see whether my work would or would not stand, and I assure you all the armour you have hitherto put on a ship gives weakness in that case instead of strength. You go bang at your ship, what do you find? You find the plates tilt out in the most beautiful manner, and when you hit upon them at a place which slightly dinges them in, the dinging in of the armour at that point tips it out at all the other points, and the armour tumbles down. I want you not to take away a single plate from the central battery of your ship, and stick it on the bow, in the belief that your bow will be one bit the stronger for the purpose of ramming. I want you to make your bow strong, but do not do it by armour, do it by something quite different. I am an old advocate for end-on fire, and I remain so; but now in our large armour-clad war ships, I am an advocate for broadside fire, because I am satisfied that the end-on work is chiefly to be done by ramming, and that it is only where the ram is not used that your guns are wanted, and then you ought to have them all on the broadside.

Admiral Selwyn: I think it would be a great pity if we could not come to some conclusion as to the method of following up the War Game which Captain Colomb has so kindly devised for us. It seems to me there would not be any great difficulty in making it a regular part of the performances in this theatre. Many of

[1] See Vol. xx, No. lxxxvii, page 475.—R. A. E. S.

our evenings are spent in much less interesting subjects than this, which might be usefully studied by the seniors of the profession, if we cannot get the younger men amongst us. We could easily form two parties, and obtain an umpire sufficiently firm and well obeyed to solve the little differences which would be sure to arise of judgment and the effects of certain circumstances. Of course this must be in a great measure for the judgment of the Council, but I think if a strong representation is made from the meeting that such a thing is desirable, they will be able to afford the opportunity.

Next I would point to the fact that, desirable as it is to conduct experiments like the Russian experiments, it is mainly difficult in this country on the ground of expense; but as soon as we get our motive power with a little less fuel, we shall probably be able to get what we want. I hope to be able to give you some information on that very shortly, and to show that a vessel of 800 tons and 900 indicated horse-power has been working steadily on less than one pound of coal per indicated horse-power, in other words halving the ordinary expenditure. It is not a simple experiment, but it is a definite fact.

With regard to the types of ships which have been indicated, I am one of those who would be very reluctant indeed to see types adopted. I say you may much more usefully prepare your minds for great advances in directions not now appreciated or known, and it would be a great error to set down here any type of broadside or end-on fire ship as the most desirable. I believe when we play our war game the profession will learn very much more from finding out "how not to do it" than from finding out "how to do it," because if there was or could be a perfectly plain system of fighting an action at sea, that system would be sure to be avoided, but we may learn how not to fight.

With regard to the question of protection of armour, to which Mr. Scott Russell has adverted, I think we may say even a little more. That armour has never been carried to the keel, and shot coming from a distance which happened to strike the bow would go out through the keel, and no existing armour would be any great protection. You may protect the gun, but if you do not protect the ship and the engines it is very little use protecting the guns and men. The ram attack is a question of speed and lasting speed. That is the whole question. You may have the most splendid seamen in the world, the most splendid artillerist or manœuvrer, but if he has a ship two knots inferior to his enemy in speed he cannot win. It is the old story over again. Speed, lasting speed, is the main function which settles all the conditions of a naval combat; and I do not anticipate, if we ever have to fight with ironclads meeting each other at sea, that we shall know exactly what ironclad it is that we meet, so that we shall be able to say, "that "vessel has so much armour, so many guns, so much everything." We shall very rarely be able to do it. We may meet quite a new ship, of which the conditions are not known. I quite acknowledge it is absolutely necessary in a War Game to lay down certain conditions, but I think those conditions should be one ship against the other costing about as much, but do not confine them in speed or other particulars. Say "I will take such a type of ship as my ship, you choose another." Fight the two, and see what they will do, our object not being so much to show superiority of one manœuvrer over the other as to show what can be done with each class of ship. In that way we should learn very much, quite equally whether you gave a pawn to your adversary or even a castle, or whether he takes one from you.

Admiral Randolph: The lecturer says, "Two elements clearly govern the pro-"bable value of shot fired, the distance of the target, and the angle at which the "shot would strike. A third element comes in for ships in the size of the targets "vertical and horizontal, which vary according to the angles the path of the shot "makes with the line of keel." I wish to inquire whether Captain Colomb means to ignore any difference as to what part of a ship is struck by the shot—whether all parts are considered equally vulnerable, that is, whether a shot striking, say at the waste water pipe, or entering a port, or at the water edge between wind and water, is estimated at the same value as a shot striking the most invulnerable part of the ship? In other words, whether the comparative value of the side and end-on hits is to be estimated only by the angle of incidence?

Captain J. C. R. Colomb: That question as to the relative value of speed is a

very important one. It appears to me the war game may throw a good deal of light upon it. My only object in rising is to say I think it is very desirable to try one thing at a time. The main principle it appears to me to be discussed this afternoon is the relative importance of broadside to end-on fire. Of course I cannot pretend to a technical knowledge of this subject, but as one taking considerable interest in it I think a great deal of confusion and misconception has arisen from trying to settle too many things at once.

Captain P. H. Colomb, in reply, said: I think the discussion has shown very clearly—as my brother has expressed it—that the chief difficulty in discussing these questions is to avoid trying to do too many things at once. We try, in point of fact, to run before we are in a condition to walk, and the consequence is, we sometimes leave discussions in this theatre with our ideas very nearly as unsettled as they were before we entered it, if not still more so.

Admiral Randolph thought I was not quite fair to him in saying that his only endeavour was to force his adversary to occupy the stern position. My reference is to the first diagram in his paper (*a*), where he assumes—and it is the only diagram he shows where the positions last relatively for any time—that A will be able to keep B on his quarter for eight to ten minutes. Then as to the chance of the "Alexandra" being rammed, I should explain to the Admiral and to the meeting, and I have stated it in an early paragraph of the paper, that I was not really replying to Admiral Randolph; I was taking a general view of the question as it appears to me, and as it was applied to our present ships, and that I have not assumed in the paper that the ships always had equal speed. I have throughout assumed that it was possible for them to have different speeds, and I have used the effects of those differences of speed in the case of the "Alexandra," the "Nelson," "Northampton," and so on. The Admiral thought I was also hard on him in saying he had made no attempt to force his enemy on his bow. Of course it is difficult to prove a negative, but I do not find in the paper any such attempt on the Admiral's part, and I conceived that he found a difficulty in forcing the enemy to remain on his bow.

With regard to my expression that the bow guns were really weak rivals to the ram, I think the expression is legitimate, and means a good deal. You are setting up your gun weapon side by side with your stem weapon; that is to say, you are setting up two weapons, one against the other, when, if your ram succeeds, it is perfectly certain your gun is neither here nor there. And I am quite sure of this one point, that when you are delivering your ram blow you will allow nothing in the shape of gun-fire to distract your attention from that; and you will distinctly forbid the fire of the bow guns in case the smoke should interfere with you just at the last minute.

Admiral Randolph said it was not fair to pit a "Bellerophon" against a "Nelson" or "Northampton," speaking as though the "Nelson" and "Northampton" were not armoured ships. They are armoured ships: they have an armoured deck under water, armour at the water-line, and armour at both ends of the battery. The broadside guns alone are not protected; everything else is. To say it is not fair to pit the "Bellerophon" against the "Nelson" I think is incorrect. You must take ships, to compare them, of something nearly the same cost, and something nearly the same displacement. Now the "Nelson" cost 333,000*l*., and the "Bellerophon" 342,000*l*., only 9,000*l*. difference. The "Nelson's" displacement is 7,323, and the "Bellerophon's" 7,551. I do not think you could have got, throughout the whole Navy, two ships more nearly equal to compare one with the other, except in the differences of arrangement of armour and armament.

Admiral Randolph and several other speakers advocated, as far as I understood them, the continued variation of our ships, because we could not quite see how they were likely to be employed. A letter appeared in the *Times* the other day from the Chief Constructor of the Italian Navy, in which he took a very different view. He said, "We first of all determine how we are going to employ these ships before we "design them;" and he says, "We built the 'Duilio,' 'Dandolo,' and 'Italia,' with "a distinct tactical object." My whole argument is that the Italian method so far is right, and that if we were to build and arm our ships without any definite ideas at all, we should be wrong.

Admiral Randolph also said he thought it was not possible to carry the heaviest guns on the broadside, though you may carry them fore and aft. I cannot of course answer as to that. As far as we have gone, the weights we have carried on the broadside have been carried successfully, and I do not know how much further we shall go. But I most cordially concur with the Admiral when he says after all the great question is the best handling of the ships. It is the whole question, it seems to me, and I take leave to say that I think I have been somewhat misunderstood if it is alleged I have put forward anything in my paper which would repel that idea. On the contrary, in the last paragraph I have put it most distinctly. I have said it does appear to me that a ship which puts her guns in a particular place, with a particular view, may, by the good handling of that ship, be in a better position than another ship which has put her guns all round so as to avoid practically the necessity of manœuvring. The contrary is more like Captain Scott's view, placing guns so as to cover the entire horizon simultaneously, and forgetting that the movement of the ship will give the real arc of training.[1] To keep all your guns to bear on definite objects seems to me a stronger position to take up than to place your guns so that whatever happens you may be able to fire some of them.

Admiral Randolph criticised my method of valuing shot, but I think he could not have quite carried my table with him. If you look at the table, there is an endeavour to do exactly what he suggests. You can only do it very roughly, but there is the attempt to do the thing. You see, when you fire a shot at your X 300 yards off, and the path of the shot is at right angles to the line of keel, I must call that the best shot you can fire at her; if you can penetrate at 300 yards you would certainly penetrate within 300, and if you fire straight at her, broadside-on, within 300 yards, you must make a very bad shot if you do not hit her. But when you fired at the same ship in the line of keel you would first of all have a smaller vertical target to fire at, and your shot would be liable to be turned by the light iron-work ahead or astern of the battery. Therefore, I take 10 per cent. off the value of that shot. Now we are still at the 300 yards range, and shot fired at a point (say) before or abaft the beam, certainly lose something by reason of not impinging exactly normal to the armour-plates. I take off 10 points for that, and in the same way I take 10 off for the shot fired at a point from the line of keel. Then I suppose a shot fired at four points to the line of keel would strike either the broadside, or transverse bulkhead, at an angle of four points, losing so much of its value as a penetrating shot because of the angle. So that we reduce the value of these shot to half the full number. Then if we go on increasing the distance, still firing at right angles to the keel, the value of the shot would go on decreasing as the square of the distance—continually decreasing, first, because of the difficulty of hitting, secondly, because of the smaller chance of penetration according to the distance.

Captain Long mentioned Admiral Bourgois, and Admiral Elliot said there was only one thing to be done, that was to run end-on. I do not quite gather that Admiral Bourgois would run stern to stern if he could do it in any other way. But the point is this: Admiral Elliot says "I will have the stronger bow," and I presume Admiral Bourgois would make the same demand, to run stern-on he must have the stronger bow. But how are you going to secure the stronger bow? You are asking for an impossibility. The two ships can go on strengthening the bow till they come to the limit of strength, and then they are equal. Then, to be reasonable, you must make a stem to stem encounter a drawn game, and I am quite satisfied nobody in real action will make a stem to stem encounter if he can avoid it; he will very often come close to it and avoid it just at the last minute. I think Sir Spencer Robinson really sufficiently answered Admiral Elliot. The difficulty in working the war game is to work it under distinct conditions, and under circumstances when we shall all be in agreement as to what is a loss and what is a gain. If you vary the armour and the guns in the ships, immediately you come to questions that are as yet insoluble, you get no further after the whole of your battles. But if, on the contrary, you take two definite ships and work them on paper in his way, your ideas will be wonderfully changed and very much enlarged and opened—very much more so than people are apt to think at least—because there is between those ships, as we

[1] See the rise of this idea in "Our Ironclad Ships," page 235.—P. H. C.

may fight them hereafter, the single difference of placing the guns. If everything is the same, except at this or that point, you will come to something like a conclusion as to which is the best way of placing the guns under those conditions. Then you may say, " Now we have got that, we will introduce another condition; we will in-" crease the speed of one ship." We shall then come to know the relative value of broadsides and end-on when speeds are unequal, and so we shall go on till we get definite conclusions on that head also.

Admiral Elliot also argued against my view, that if guns were taken away from the broadside at all, they ought rather to strengthen the stern than the bow, and he used this singular expression: " If once I got on his quarter that ship is mine," meaning if he had superior speed. But that is what I have been saying all along. Admiral Elliot was rather fighting the war game without the necessary materials. We must pin ourselves down to very distinct and accurate conditions, or we get off the line of rail on which we ought to pursue our argument.

I am sure I have to thank all the speakers for the exceedingly complimentary way in which they have spoken of my small labours. This question of the war game is one which has long been in my mind; but the actual work I have had in devising this particular war game has really been very small. It so happened that my mind was prepared for it as soon as I got the " Thunderer's " experiments, and it became a very easy matter to turn those experiments to account in a form which no doubt will be improved upon, but under which, I cannot help thinking, there will be found some real stuff.

Captain Bridge did me only justice in thinking that I never would have lightly omitted to mention Captain Grenfell's splendid elucidation of the value of the Harvey torpedo, which I may perhaps be pardoned for saying I think killed that torpedo. I have in other places and at other times done the fullest justice to Captain Grenfell, but as I have said, that was a single point. Admiral Randolph has taken the whole question, he has taken two ships and fought them out, which nobody else has ever done. The only person I know of who has at all approached him is Captain Noel, in the essay which won the prize in the Junior Professional Association at Portsmouth. He took two fleets and led them up to one another and partially fought them, but he did not carry it through. Admiral Randolph has carried the thing right through, and has taken every possible sort of position in which a duel can be fought, and has thoroughly attacked that distinctive tactical problem. I do not think anybody else has done that before. Captain Bridge spoke of the change of opinion as to the end-on fire being due to the changed conditions which are chiefly influenced by the speed, but I think this is exactly the question we want to argue. Is it true that this power of keeping your speed should make you draw away your guns from the broadside, and put them on end-on, and especially at the bow? I fail to have heard any definite reasoning on the subject, and I do not think definite reasoning is to be got at except by experiment on paper, such as we propose here, and afterwards by experiment at sea.

Captain Bridge also spoke of the necessity of allowing for the chapter of accidents in the naval war game. I think I have considered that subject thoroughly. You have to recollect that the war game amongst military men is not to establish facts; it is to cultivate skill. Your facts are known; you know exactly what is the right thing and what is the wrong thing to do on shore amongst troops, because you have all the experiments of war before you. Under the present conditions, we in the Navy have no facts whatever to go upon, and our war game, for many years to come, until—as I hope we never shall—we have the opportunity of carrying out in fact on the ocean, it can only show us not individual skill, but the method in which we are to arm our ships and use them afterwards.

Captain Scott spoke of the " Enterprise " as to " end-on " fire. It was simply that the guns shifted; there was no actual withdrawal. He also appears to omit the fact that the movement of the ship itself will always give arcs of training, and that if you have a skilfully-handled ship you will get your arcs of training by the movements of that ship, and the necessity of providing for arcs of training appears to me to be going into the background, and not forward.

Then as to yawing, I must express a somewhat definite opinion. Many years ago, when I was in command of a small vessel, I used to practise it continually. I had

very few guns in the ship; they were heavy, and I felt if I were called into action the chances were I should either be the following ship or flying, because there were other ships of my size with more numerous guns on the broadside. I used to make very fair practice indeed with continually yawing, firing broadsides, and I think at any reasonable distance firing broadsides by word of mouth or electricity you will make very fair practice indeed.

I sometimes disagree with Admiral Selwyn, and I am exceedingly glad to be in agreement with him now. I think he put the case quite properly when he said the way to argue these questions is by means of the war game. I think, however, that too much stress has been laid upon the necessity for an umpire, for it seems to be considered that the umpire will have a great deal of work. So far as my short experience of it goes, there is very little for the umpire to do. His only work is when you have missed your aim by a yard or two ramming; up to that moment the umpire has practically nothing to do. When the game is published you will see what use there is for the umpire to decide before the game begins, because practically the umpire must represent the chapter of accidents that Captain Bridge spoke about. He will decree the number of minutes the fight is to last, and he will stop you at that time, as you would be stopped in actual war by the presence of a superior force; by driving your enemy into shallow water; by neutral waters, and so on, and he will also, when he thinks proper, pop a shoal down close to you when he wants to vary the game. But as to actually deciding, I think we shall find the points are generally so clear that the umpire will have little more to say than in a game of chess.

Admiral Selwyn seemed to say that enemies would not fight on an equality. I think that is exactly the ultimate result of all tactics. You saw that in the establishment of a line-of-battle. They fought on an equality from the time the line-of-battle was adopted by the Dutch till Nelson showed them a better way. Nobody had thought of anything beyond it. And that will be the case, I take it, in naval war, that when each side has got that which is really best—not best in his opinion, but really best—in both nations then you will fight on an equality. But I think the tactician's aim is to make sure that he is not fighting *on an inequality;* that is what he has to look for. There is one other point I wish to correct. I think when we come to examine by means of these scales, we shall see that speed itself will not give you the power of ramming. When two ships are approaching end-on close to one another, the man who keeps his nerve and his wits, and understands thoroughly what he is about, and has the best steering apparatus, will know perfectly well that the stem of the other ship will never touch him. The least touch of the helm when the ships are nearly end-on to one another will make them certainly pass broadside to broadside, rub, and so on. To effectually ram you must have, as well as speed, the superior turning power. If you have not the superior turning power it will be very difficult indeed, first of all, to ram, and, secondly, to avoid being rammed yourself.

The CHAIRMAN: I should like to ask Captain Colomb whether he has any objection (in his preference for the broadside arrangement of armament) to allow the bow gun on each side to be trained right forward if the Construction Department makes no objection to it. I know it is possible for him to say "I have made up my "mind that that is the proper way to place my guns, viz., for broadside firing ONLY, "and I will not accept the power to fire the two foremost guns right forwards, and "the two sternmost guns right aft, as I think it would be a temptation to the "Officers in command to begin their action at long ranges when they are running "towards the enemy, and therefore I would block up that port if it was made for "me." I should like to ask that question.

Captain COLOMB: I am most anxious for bow fire if I get it without too great a sacrifice. If you show me a method by which you give me the power of firing my broadside gun as a bow gun or a broadside, I have no objection to the "Hercules" system at all except the second port, and really I should not care very much about that.

The CHAIRMAN: I am very glad to learn that Captain Colomb has no objection to two of his guns being able to be pointed right forward and two right aft, and he would of course leave it to the discretion of the Captain who is going to engage the enemy

as to whether he opens fire from that gun trained right ahead or on the bow or keeps it trained on the broadside. Therefore in point of fact he has no objection to his guns being placed on that principle, provided always that these ahead guns can be fired on the broadside: that seems to me the desideratum. All guns to be able to be fired on the broadside, and two of them are to be fired ahead and two astern, a combination of broadside and right ahead.

Allusion has been made to the Russian experiments. I had the opportunity of seeing what was done at St. Petersburgh, and I must express my regret that our Admiralty, for some reason or the other, do not direct the Commanders-in-Chief on foreign stations to set their young Officers to try experiments in ramming with their launches, protected as they are always in Russia by fascines, so as to exercise them in this matter. If we are to have Captain Colomb's war game it will be very instructive to all of us, old and young. I hope their Lordships may in some way or other do as the French Admiralty do, that is, encourage young Officers at the home ports and on foreign stations to practise this game, which may be divided into (1) games of skill where the ships are alike; (2) games to test merits of arrangements of armament, one person fighting both ships; and (3) mixed games in which skill and merits of armament are both tested. In France young Officers are almost forced to attend on certain evenings at lecture rooms specially provided in each Dockyard to discuss important questions of naval tactics. Captain Colomb's game will be introduced immediately. When I was at Brest I asked what the discussion for the night was, and was told that it was what Villeneuve ought to have done at Trafalgar instead of what he did do, and that on the previous day the subject was what ought to have been done by Admiral Brueys when Nelson attacked at the Nile and destroyed the French Fleet, and could anything have been done to prevent or diminish Nelson's success. Young Officers who joined in such discussions and war games were likely to form much better tacticians hereafter than those who did not, and they should be encouraged. Secondly, I never could understand why we do not hear the results of the important experiments going on constantly in our large squadrons, the Channel Fleet and the Mediterranean Fleet, in the matter of evolutions. We have had I do not know how many squadrons of evolution during the last ten years. Admiral Randolph commanded one of them, and was second in command of another. I have no doubt his mind and his memorandum books are full of important information which he collected. The drawers of some rooms at the Admiralty are full of reports from our best Officers on such subjects as "groups," how best to handle them in action. I have no doubt that Admirals Hornby, Beauchamp, Seymour, Commerell, and numerous others have arrived at conclusions having the force of axioms. Those Officers who have not had the good fortune to belong to these squadrons know absolutely nothing about what has been done, what conclusions have been arrived at. There are Officers on shore on half-pay who would be delighted to be allowed to witness these evolutions in a vessel attached to the fleet for the purpose, and I think they ought to be encouraged to do so, for by that means and by that alone can they obtain that amount of knowledge which is so absolutely necessary and would be so much prized. I am not speaking for my own advantage, my naval career is well nigh ended. I speak in the interest of the country and of the junior Flag Officers and senior Captains.

I have now to thank Captain Colomb on your behalf for his most interesting paper, and to assure him that the Council of this Institution will be asked to facilitate in every way the carrying out of the naval war game in this theatre.

Evening Meeting.

Monday, March 3, 1879.

Lieut.-General Sir HENRY LEFROY, K.C.M.G., R.A., F.R.S., in the Chair.

ON THE PRODUCTION OF STEEL, AND ITS APPLICATION TO MILITARY PURPOSES.

By C. W. Siemens, Esq., D.C.L., LL.D., F.R.S., &c.

The Chairman: It is scarcely necessary for me to remind you that you have before you one of the most distinguished physical philosophers of the present day. We have to do to-night, not with the distinguished electrician, with the constructor of the "Faraday," with the inventor of the bathometer, with the fertile inventor whose range has gone over subjects as various as the setting of type, and the measure of the depth of the ocean, but with one of the most scientific metallurgists of England, the inventor of many remarkable processes in that art, and particularly of one which I daresay he will allude to for the direct extraction of steel and iron from the ore, and of whom it may be very safely said that he has touched no subject which he has not adorned.

Dr. Siemens: The subject-matter regarding which I propose to engage your attention this evening is not new. Steel was known to the ancients, and is still produced by semi-barbarians in a similar manner to what we find described in ancient records. Rich ferruginous ores were placed upon ignited charcoal in a cavity formed in the side of a hill, and as the result of a day's hard labour in activating goat-skin bellows, a lump of metal mixed with charcoal and slag was produced, which after being subsequently forged, would prove sometimes of a comparatively soft nature, when it was called iron, and at other times harder when it was denominated steel. This shows that the two metals iron and steel are substantially the same, and that they are distinguishable only by difference of physical qualities which are the result of very small chemical admixtures.

The steel produced by the ancients was of very high quality, remarkable for its great hardness, and for its power to resist abrasion. Who has not heard of the blades of Damascus, and at a somewhat later period of those of Toledo, and of the remarkable swords that were made by the Norsemen? So much value indeed did the Norsemen place upon the production of cutting edges of great hardness

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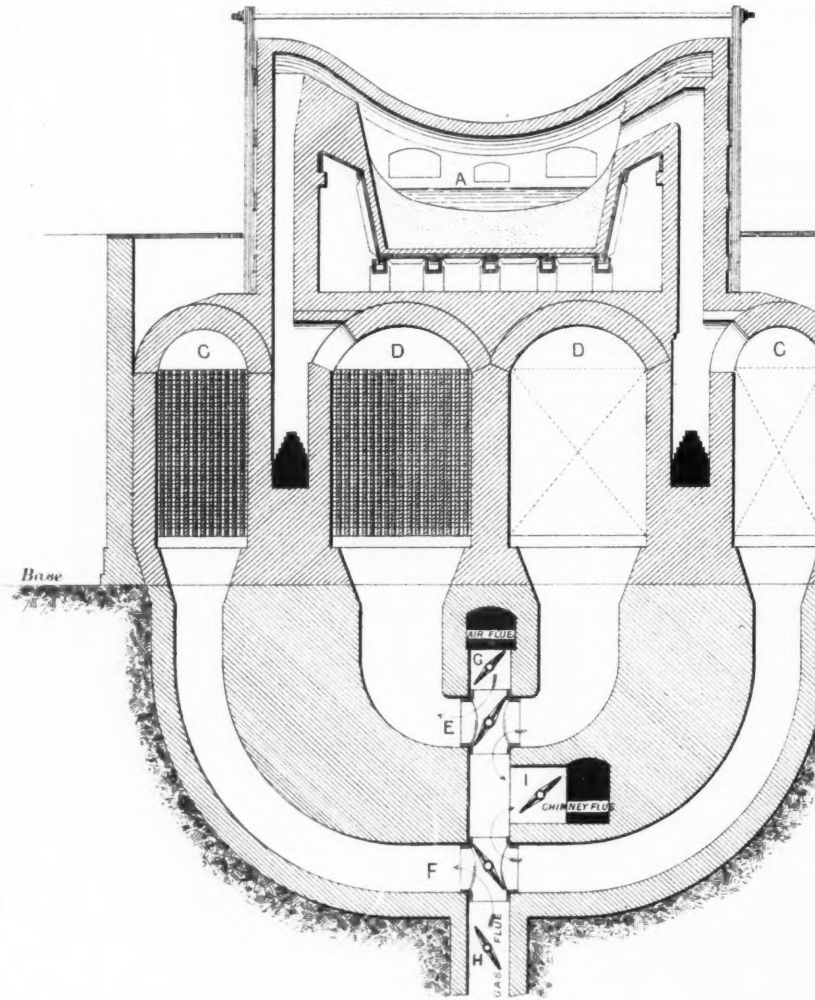
Fig 1.

Longitudinal Section



Scale 1/8" = 1 Foot

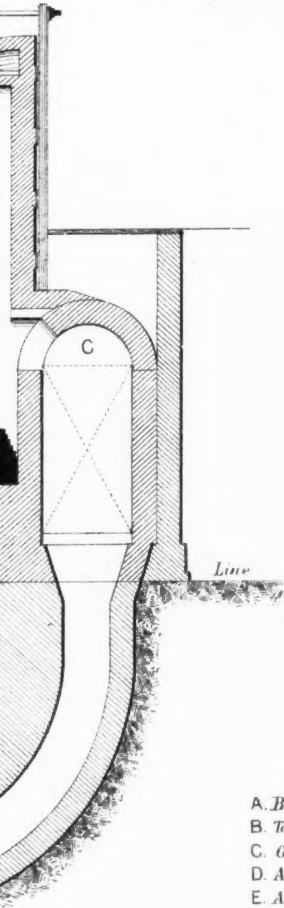
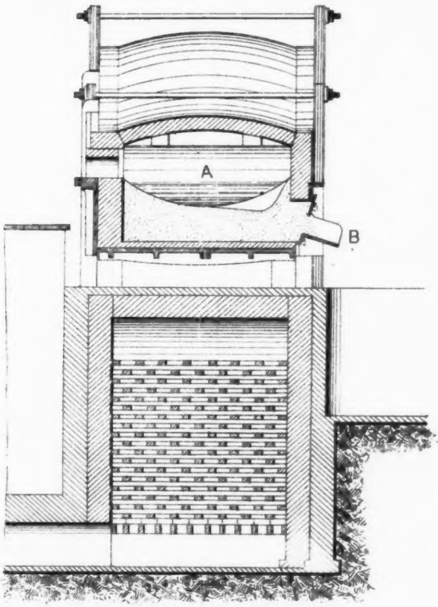


Fig 2.

Cross Section.



A. *Bed of Furnace.*
B. *Tap Hole.*
C. *Gas regenerators.*
D. *Air , do*
E. *Air reversing valve.*
F. *Gas do . do.*
G. *Air regulating valve.*
H. *Gas . do . do.*
I. *Chimney damper.*

...le 1/8" = 1 Foot.

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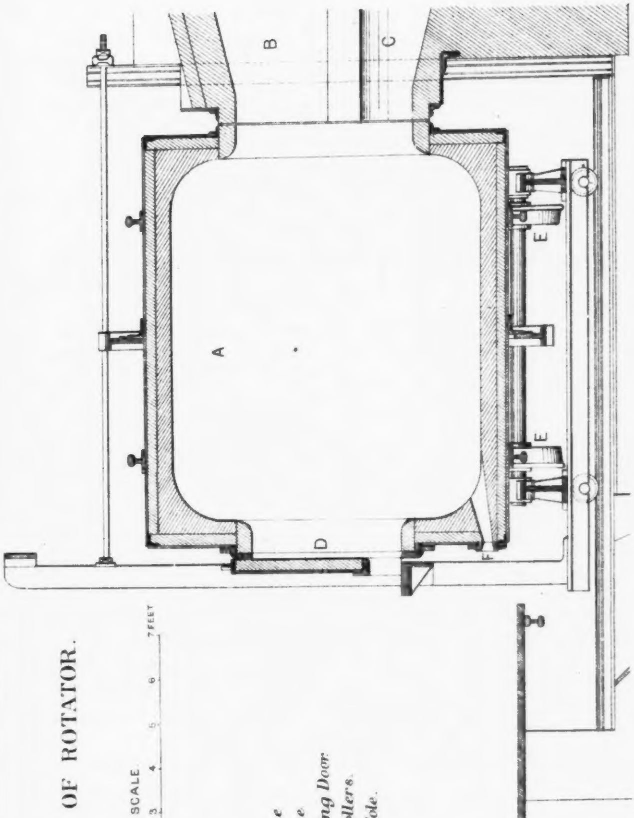
Fig. 3.



SECTION OF ROTATOR.

SCALE 0 1 2 3 4 5 6 7 FEET

A. *Drum*
B. *Air Flue*
C. *Gas Flue*
D. *Charging Door.*
E. *The Rollers.*
F. *Slag Hole.*

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coupled with tenacity to resist chipping, that those who could produce a blade of unequalled edge were highly esteemed, and in one or two instances even rewarded with the purple of royalty in being elected sea kings.

Notwithstanding the antiquity of the metal called steel, its production and its application have taken a new and very remarkable stride within our recollection. It was, however, as early as the year 1722, that Reaumur, the distinguished French philosopher, proposed to produce steel on a large scale by fusing cast or pig metal with wrought metal or scrap. He put these ingredients into a crucible, and melting them together produced a metal partaking of the nature of steel. The difficulty he encountered, however, was insufficiency of heat. As far as we can make out, Reaumur's suggestion amounted to little more than a proposal, and it was not until 1820 that steel melting was introduced into commerce in a successful manner by Huntsman of Sheffield, using coke in a furnace actuated by intense draught, such as we know at present as an air furnace. Huntsman succeeded in melting steel in considerable quantity in pots, and from that date steel has become of great value in commerce for various applications.

Steel has variable properties depending upon very slight differences in chemical composition. Thus one steel when hardened will be next to diamond in its power to resist abrasion, and in its suitability to cut other metals, or when drawn out it will show a permanent elasticity not equalled by any other substance; it is susceptible of retaining magnetism, and will become what is called a permanent magnet, which property is shared with it to an inferior degree by only two other metals, nickel and cobalt. It is now produced in another condition known as mild steel, in which it manifests a quality of a totally different kind, a ductility not equal only but superior to that of copper and silver.

I hold in my hand a vase that has been wrought from a bar of this mild steel by an ordinary blacksmith, or I should rather say by an extraordinary blacksmith, because upon examination the workmanship displayed in the production of this vase is found to be really astonishing. The vase is hollow throughout, and not more than $\frac{1}{32}$ of an inch in thickness and perfectly sound, without weld or soldering. For this work of art I am indebted to my esteemed friend Mr. Henri Schneider, of the celebrated Creusot works in France, who has forwarded it to me as a sample of what he had produced by the open hearth process of steel making, of which process I shall have occasion to speak further on.

It was not, however, until the year 1856, that a means was proposed of producing steel at a cheap rate. This was the year when Mr. Henry Bessemer read his famous paper at the meeting of the British Association at Cheltenham. His paper was entitled "The manu-"facture of malleable iron and steel without fuel," and it naturally created the greatest possible interest throughout the country. Mr. Bessemer, however, did not immediately succeed in producing by his process such steel as could be used. It was not until the year 1862, the time of the Universal Exhibition in London, that Bessemer steel

attained a decided position in commerce. But, in speaking of this very important process, I feel in justice bound to make reference to the name of Mushet, who, when he heard of the Bessemer process, thought that it would require an addition—analogous to what Heath made in the Sheffield pot-melting process—that of manganese. Mushet proposed and patented a mode of adding spiegeleisen (or pig metal containing a considerable percentage of manganese) to the Bessemer metal whilst it is still in the liquid state, thereby separating from it the oxygen held in suspension in the metal in consequence of the blowing, and as we now know, adding to it some manganese which is essential in order to make the metal thoroughly malleable. We have here then a process that has done more than any other invention in modern times to revolutionize, I may say, the most important industries of the land. At present not only railway machinery, but the very rails upon which we travel, are made not of iron, but of steel, and if I say that steel rails have shown a power of endurance five or six times greater than those of iron, I may add, with some regret (and I now speak not as a consumer, but as one connected with the production of steel as a manufacture) that they are unfortunately produced at a price almost cheaper than iron or any other metal that could be named. Perhaps, however, the manufacturer will learn to produce them at those prices and yet clear some profit.

Almost at the same time that Mr. Bessemer made his remarkable invention experiments were instituted, at a distance of not 100 yards from this place, which have led to another process of producing steel upon a large scale. I, in conjunction with my brother, Frederick Siemens (who had previously been my pupil), erected an experimental furnace at Scotland Yard, by which we proposed to attain very high degrees of heat, and it was almost from the first that I looked upon that furnace as capable of accomplishing what Reaumur, and after him, Heath, had proposed to do, namely, to produce steel in large quantities upon the open hearth.

At first our attention was confined to melting steel in crucibles, to melting glass, and to other applications of this mode of producing intense heat; the difficulties encountered were very great, and it was not until the year 1861 or 1862 that the prejudices in the way of the practical application of the furnace were sufficiently overcome, and that the furnace itself had assumed such a shape as to enable us to show that it could be applied with commercial advantage. And it is a curious coincidence that it took us just as long to mature this furnace as it took Mr. Bessemer to mature his process. In the year 1861, a large furnace was erected at the glass works of Messrs. Lloyd and Summerfield, near Birmingham, which has been at work up to the present time, and has realized those results that we, up to that time, had only hoped to attain. The success then achieved encouraged me to commence a series of experiments in the direction of producing steel on the open hearth, but, in order not to weary you, I will proceed to describe the regenerative gas furnace in the form in which it is now applied for the production of steel on the hearth, in quantities of from 5 to 10 tons at a time.

The regenerative gas furnace is so essential a part of the process of open hearth steel making that it is indispensable to describe its principle and construction to some extent. It consists of two distinct parts—the furnace proper, with its reversing valves, regenerators, and melting chamber, and the gas producer, in which the raw fuel (mostly small coal) is converted into gaseous fuel, which is thus separated from all the drossy and dirty constituents in the coal. It would appear, at first sight, a roundabout operation to convert fuel from the solid into the gaseous condition and then to take and burn this gas in a furnace elsewhere; the gas, as it passes from the producer, is in a heated state, and in its transit to the furnace a great deal of that heat must necessarily be lost; therefore, it might well be asked, why make this conversion of solid into gaseous fuel? Surely, in burning the gas less heat is obtained than if the fuel were burnt in the heating chamber of the furnace, and produced its effect there. That would be perfectly sound argument, if it was not for the regenerators of the furnace. These regenerators are by far the most important part of the whole arrangement, and, in order to understand the general principle of the furnace, I will first describe their action.

The drawings represent the furnace, the one being a longitudinal and the other a cross section; the gas coming from the gas producer passes in through what I call a reversing valve, by means of which it is directed into the bottom part of the regenerator chamber. The gas flowing up through the mass of brickwork the chamber contains, and which is placed so as to form a large aggregate surface, with intricate zigzag passages, will become heated, provided any heat has been accumulated therein. In the first place, there will be no heat, and the gas will pass unheated through this chamber and thence to the combustion chamber of the furnace. At the same time, a current of air is admitted through the air-reversing valve into the air regenerator chamber, which is larger than the gas chamber. The air passing up through the chequer work will reach the same point as the gas does at the entrance into the combustion chamber of the furnace. Now, since both the air and gas are cold, and as they meet for the first time at the entrance into the furnace, they will, if there ignited, produce a heat not certainly superior to what would be produced if solid fuel had been burned there instead; on the contrary, gas of the description we are dealing with is a poorer fuel than solid fuel, and the heat produced in the furnace will, therefore, be very moderate indeed. But the flame, after passing over the bed of the furnace, does not go to the chimney direct, but has to pass through two regenerative chambers, similar to those already described; the larger proportion of the heated products of combustion will pass through the air regenerator chamber, simply because it is the largest channel, and another portion will pass through the gas regenerator. The products of combustion pass from these chambers through the reversing valves, and are by them directed into the passage leading to the chimney.

The operation, therefore, is simply this, that the air and combustible gas pass up into the furnace through the one pair of chambers, and pass away, after combustion, towards the chimney through the other

pair. But in passing through the second pair, the heat of the products of combustion is given up to the brickwork. The upper portions of this brickwork take up the first, and, therefore, the highest degree of heat, and, as the burnt gases are passed downward through the regenerators, they are, by degrees, very completely deprived of their heat, and reach the bottom of the chambers and the chimney comparatively cold. After this action has been going on, say, for an hour, the reversing valves are turned over. They are simple flaps, acting like a four-way cock, and, by throwing over the levers which work them, the direction of the currents is reversed. The gas and air will enter now through the second pair of chambers, and the air passing up one regenerator and the gas passing up the other, will take up heat from the bricks previously heated by the descending current. The gases so heated, say, to 1,000° F., will enter into combustion, and if the heat produced at the former operation was 1,000°, it ought this time to be 2,000°, because the initial point of temperature is 1,000° higher. The products of combustion will also escape at 2,000°, and passing through the chequer work of the first pair of regenerators, its uppermost ranges will be heated to very nearly 2,000°. The temperature will diminish by degrees in descending till the gaseous currents have again reached the bottom nearly cold. Again reversing the process, after another hour or half hour as the case may be, the gas will take up heat to the extent of nearly 2,000°, and since another 1,000° is again produced in combustion, the temperature of the furnace will this time attain 3,000°, and in this way it might be argued that, unless work is done in the furnace, the heat developed in combustion will, step by step, increase the temperature of the furnace 1,000°, or something less, each time a reversal of the valves takes place, till we arrive at the practical limit imposed by the melting point of the most refractory substance we can find (pure silica, in the form of Dinas brick), of which the melting chamber is usually formed. This high temperature is obtained by a gradual process of accumulation, and without any such current as would be likely to destroy, by oxidation, the metal in the bath, or cut away the sides and roof of the melting chamber.

There is, however, a theoretical as well as a practical limit to the degree of heat obtainable in combustion, which was first pointed out by M. H. St. Claire Deville, namely, the point of dissociation at which carbonic acid would be converted back into its constituents, carbon and oxygen. If carbonic oxide or any other combustible gas and air enter the furnace at a temperature very nearly equal to the point of dissociation, it is evident that association or combustion cannot take place, and thus nature fortunately steps in to restrict the increase of heat by accumulation, within comparatively safe limits. In a furnace fully heated up to the melting point of iron, this action of dissociation can be very clearly observed. At first, when the gas and air are comparatively cold, combustion takes place sluggishly, the gases will flow through the furnace and produce only a dark-red flame; the next time the valves are reversed a whitish flame is produced; the next time a short white flame; and after having reached

a full white heat, exceeding the welding point of iron, the flame will again become a long one, but this time not red, and of little apparent power, but bluish white, and flowing in clouds. This indicates the near attainment of the point of dissociation; combustion can no longer take place, except in the measure of the heat being dispersed to surrounding objects, or to the metal in the furnace, and that is about the degree of heat required for the process of making steel on the open hearth.

Before I leave the question of the furnace, I must refer back to the apparatus in which the solid is converted into gaseous fuel. This is a very simple apparatus consisting of a cubical brick chamber of about 8 feet side, one side of which is cut off in a slanting direction. Fuel descends on this inclined plane, to the grate at the bottom where combustion takes place. The result of this combustion is carbonic acid at a high degree of temperature, and if this product of combustion was allowed to pass up the gas-collecting channel, and through the overhead tube to the furnace, there would be nothing to burn; and the only result we should probably observe would be that the iron tube would very soon become red hot, and be melted down. But the carbonic acid, as it is formed near the grate, encounters a further layer of fuel descending from above, which is also incandescent, but which cannot be consumed on the same terms, because there is no longer any free oxygen present. The first result of combustion being carbonic acid, a compound of one atom of carbon and two of oxygen, this carbonic acid in passing through the subsequent layers of incandescent fuel is broken up, and a second molecule of carbon is added to the first, thereby producing carbonic oxide, which is a combustible gas. But coal is not simply carbon, it consists also of volatile matters, hydro-carbons, water, and the constituents of ammonia, and the hot carbonic oxide, in passing through a further thickness of the fuel which contains these gaseous constituents, acts upon them in the same manner as heat does upon the coal in a gas retort. This action absorbs a portion of the free heat in the carbonic oxide, and the result is a gas consisting of carbonic oxide, hydrogen, hydro-carbons, aqueous vapours, and nitrogen, which latter, being a constituent of atmospheric air, necessarily passes with it through the fuel, and dilutes the combustible gas produced to the extent of about 50 per cent. of the total volume. This combined gas leaves the producer not at 3,000°, the temperature of direct combustion, but at about 700° F. only. This remaining heat is thrown away and purposely so, and many criticisms have been made in consequence of this apparent waste of heat in the regenerative gas furnace, but I think I can prove that although there is loss of heat, no waste is incurred.

The gases passing from the gas producer could be forced to the furnace by mechanical means, but this would be very troublesome and costly, and the duty performed by the 700° of heat is to give them onward motion in the direction of the furnace. The hot gases rising in the uptake represent a column of heated gas at a temperature of 700°, at which its density will be about half the density at ordinary temperature. From the uptake they pass through a long tube of sheet

iron or steel, and on their journey through this horizontal tube they part with most of their heat, so that when they reach the downtake their temperature has probably fallen from 700° to 200°, having parted with 500° of heat by radiation from the tube. The consequence is that the descending column will be of about twice the specific weight of the ascending column, and therefore a continual flow of the gas will take place, ascending on the one side, and descending on the other in forcing its way towards the gas furnace; by this means the heat apparently lost in the gas is utilized to produce useful mechanical effect.

But suppose that the gas passed from the producer to the furnace without being allowed to cool, what would be the result? The gas would enter the regenerative chamber at a temperature not of 200° but of 700°; it would, in ascending, take up more heat and enter the heating chamber at the temperature previously imparted to the upper ranges of the chequer work by the descending current or product of combustion. The same temperature would be attained by the gas if it entered at 200°, the only difference being that the regenerator in the case of the cooled gas would work through a greater range of temperature by 500°. But a regenerator will work with the same economy through a greater range as through a less range, therefore, this heat, if it could be saved, would be of no benefit whatever to the gas furnace. The only difference in result would be that the gases would get less cooled in descending on their way towards the chimney, and that we should have a hot chimney instead of a comparatively cool one. Therefore, no loss to the furnace is incurred in cooling the gas on its way to the regenerative chambers, and the temperature of the gas is utilized to produce the very essential mechanical effect of urging the gas from the producer to the furnace.

The economical action of the furnace depends upon the circumstance that the products of combustion reach the chimney, not at the temperature of the heating chamber, as is the case when ordinary furnaces are employed, but at a temperature not exceeding 300° or 400° F., thus rendering nearly all the heat produced in actual combustion available for accomplishing useful work. It will be readily perceived that the economy of this system must be greatest in melting steel or in accomplishing operations of melting or heating at very high temperatures, whereas for the attainment of low temperatures, such as the heating of boilers, the economy would be comparatively small. Its practical economical result for high temperatures is well illustrated by the fact that in melting steel in pots in the ordinary air furnace at Sheffield, 3 tons of Durham coke are required to melt a ton of steel, whereas a ton of small coal suffices to melt a ton of steel in the same pots when the regenerative gas furnace is employed. In melting steel in bulk upon the open hearth, the consumption of fuel is further reduced, and does not exceed 12 cwt. of coal for the production of a ton of steel. In re-heating iron, the practical economy effected in the regenerative gas furnace over the ordinary furnace amounts to from 40 to 50 per cent., owing to the inferior degree of temperature required. When applying the system

to inferior temperatures, there is advantage in suppressing the cooling tube and gas regenerator, and in approaching the gas producers to the furnace, to consume the gas at its initial temperature.

At large works such as are now erected for carrying out the open-hearth steel process, a cluster of producers are put up outside the works; and the fuel is delivered from the railway at an elevated point in order to be put into the producers in which it is gradually consumed, and flows as a gas through the large overhead tubes into the works where a number of furnaces are supplied for the production of steel. I think these observations may suffice to describe the furnace which plays a most important part in the process to which I shall presently refer.

I have already stated that one of the chief objects I had in view in maturing this furnace was the production of steel on the open hearth, but, as usual, in introducing a new process, great difficulty was encountered in first attempting to carry out that idea. The question arose whether steel could be melted and maintained as steel upon the open hearth of a furnace at a temperature exceeding the melting point of most fire-bricks. The general opinion of practical men was entirely opposed to the idea of accomplishing the object, and it is, therefore, perhaps natural that its realization was a question of time. The first attempt to make steel on the open hearth of a regenerative furnace was made by Mr. Charles Atwood, of Tow Law, who, in 1862, agreed to erect such a furnace—a small one, it is true—to my design; but although he was partially successful, he abandoned the attempt because he was afraid that the steel so produced would not be of the proper quality. In the following year, another attempt was made in France. A large furnace was erected at the Montluçon works, and my colleague in the experiment was a very celebrated French metallurgist, the late M. le Chatellier, Inspecteur-Général des Mines. The experimental results were on the whole satisfactory. We obtained some charges of metal that was decidedly steel, but, unfortunately, the roof of the furnace soon melted down, and the Company who had undertaken the erection of this furnace were so much disheartened that they, for the time at least, abandoned the idea of following up the trials. After two or three very similar disappointments, I decided to erect experimental works at Birmingham, where the processes of producing steel on the open hearth have been gradually matured, until they were sufficiently advanced to entrust them into the hands of others. But another French manufacturing firm, MM. Martin, of Sereuil, undertook to erect a regenerative gas furnace that could be used for making steel on the open hearth, but which, in the first place, was to be used as a furnace for heating wrought iron. While I was engaged at Birmingham with experiments to produce steel of good quality by my process, MM. Martin also succeeded in obtaining results with the furnace I had designed for them. At the time of the French Exhibition, in 1867, MM. Martin brought forward their excellent exhibits, for which they soon got a considerable name. I also sent samples of steel produced by me at Birmingham, differing from those sent by MM. Martin as regards the material used in the process; they

had turned their attention to the production of steel by dissolving wrought iron in a bath of cast iron, whereas my efforts were directed, from the first, to the use of cast iron and ore for the production of open-hearth steel.

In the process as it is now carried on at the Landore and other works, both scrap metal and ore are employed, in conjunction with pig metal and such other ingredients as serve finally to adjust the quality of the steel. The process may be described as follows:—The furnace having been heated up to the steel-melting point, or, say, 3,500° F., the first duty of the steel melter is to see that the silica bottom and tapping hole are in the proper condition for work. If, in consequence of wear caused by previous charges, the surface-bed should be pitted, white sand, previously calcined, is introduced in such quantities as to fill up the inequalities, and heat is allowed to act for eight or ten minutes with the furnace doors closed, by the end of which time the silica or white sand introduced will be partially melted and consolidated with the older portion of the furnace-bed. The tapping hole is filled up with white sand mixed with powdered anthracite or coke, which serves to prevent its entire consolidation, and thus facilitates the tapping of the furnace at the end of the operation.

These preliminary operations completed, the furnace is charged with, say, six tons of pig metal, mixed with two tons of such iron or steel scrap, as gits, spillings of previous operations, old iron or steel rails, that may be available. The furnace doors are thereupon closed, and heat is allowed to act upon the charge for two hours and a half, when it will be found to have fused, and analysis would prove the metal to be in an intermediate condition between pig iron and steel, its percentage of both carbon and silicon being greatly reduced. The subsequent work of oxidation of these ingredients consists in the introduction, at intervals of about half-an-hour, of rich ores or oxides of iron, in charges of about 5 cwt. each; the immediate effect of the introduction of each charge is an active ebullition, through the reaction of the oxide of the ore upon the carbon of the metal producing carbonic oxide. This gas escapes to the surface, whereas the iron contained in the ore or oxide becomes metallic, and is added to the bath. When about 25 cwt. of ore has been thus added, a sample is taken from the bath, by means of a small iron ladle, and subjected to a simple mechanical test, whereby the percentage of carbon remaining in the metal is readily, though somewhat roughly, ascertained. If it appears from the test that the carburization is nearly completed, no more ore is added, but 3 or 4 cwt. of limestone is thrown into the furnace, which has the effect of combining with the silicon contained in the slag, and of liberating ferrous oxide from the same, which latter, being thus set free from its combination with silicon, continues the action of decarburization of the metallic bath. Samples are again taken, until the steel melter finds that, upon breaking the sample, the peculiar silky fibre is obtained which is indicative of a reduction of the carbon in the metal to 0·1 per cent. The metal is now ready for final adjustment, according to the strength or temper of the steel required.

If it is intended to produce ordinary rail metal, from 7 to 8 cwt. of spiegeleisen, containing 20 per cent. of manganese, previously heated to redness, is charged in, the bath is stirred by means of a rabble, and, after being allowed to rest for a few minutes, is tapped either into a ladle or directly into ingot moulds, arranged in groups, whilst the slag that followed the metal through the tap-hole is collected in a pit or mould prepared for its reception. The amount of slag produced depends chiefly upon the percentage of silicon in the pig metal used, and also upon the degree of purity of the ore employed in effecting the reduction, and amounts generally to 2 tons in an 8-ton charge. The yield of metal should be within 1 or 2 per cent. of the total amount of pig metal and scrap (if of a solid description) charged into the furnace, because, although the pig metal would contain some 7 or 8 per cent. of carbon and silicon, which have to be expelled, this loss of weight is made up by the metallic iron given up by the ore. The lime added near the end of the operation is useful in taking up some of the other impurities, such as sulphur and phosphorus, from the metal, although the amount so taken up is only small.

After tapping, the steel melter again inspects his furnace-bed, repairing any slight defects that may have arisen, fills up the tapping-hole, and introduces the next charge.

The time each charge occupies is from seven to nine hours, according to its character and to the heat of the furnace. When pig metal and scrap alone are used, a charge can be worked in from six to seven hours, and the proportion of pig metal employed can be reduced to from 10 to 15 per cent. of the total charge, whereas when no scrap at all is used, the amount of pig metal charged must be equal to the total amount of steel to be produced, and the reaction between the ore and pig metal extends the time of each operation by about three hours. In this respect, then, the scrap or Siemens-Martin process has an advantage over the ore process, which is compensated for, however, by the corresponding advantage in favour of the ore process, that it is not dependent upon the irregularities appertaining to scrap metal, and upon the purifying action produced upon the fluid metal first by the oxide and thereafter by the lime. It has been found generally that for small applications the scrap or Siemens-Martin process is the more advantageous, while for large applications the ore process has the advantage.

For the production of steel of special quality, such as is employed for boiler and ship plates and castings, the process is different only towards the end of the operation from that already described. The reduction is carried to a still lower degree than 0·1 per cent. of carbon, and in order to make sure that the right degree of carburization is attained, chemical analysis of a sample is resorted to. Instead of spiegeleisen, a rich ferro-manganese is employed, together with a small proportion of silica iron (a pig metal containing about 10 per cent. of silicon), which latter metal has the effect of taking up oxygen from the fluid iron, and thus preventing blow-holes in the casting. Another method of consolidating steel is that which has been introduced and so successfully carried out by Sir Joseph Whitworth. The steel upon which he

operates is made upon the open hearth of the furnace in the manner I have described; but steel when it is poured from the ladle into the moulds shrinks, and during shrinkage little air-spaces or hollows are formed, which break the continuity of the steel, although the cavity may afterwards be closed. Sir Joseph Whitworth, by applying great pressure through hydraulic agency to the steel while in the fused condition, closes up these cavities, and steel is thus produced perfectly continuous in its nature, and of such great hardness and tenacity combined, that when put, for instance, into the form of shells, some of these shells have gone three or four times through thick iron armour, and have been quite fit to go into the gun again.

The rich ferro-manganese now introduced into the market affords the steel maker great facility for producing sound metal, notwithstanding its admixture with a considerable amount of impurities, notably of sulphur and phosphorus. By its means such inferior irons as the Cleveland can be rendered suitable for the production of steel rails, and large contracts have been carried into effect by some of my licensees for converting old iron rails of mixed or doubtful parentage into steel rails.

The facility thus offered to steel manufacturers introduces, however, a danger upon which the steel user will have to fix his attention. A steel rail containing from 1 to $1\frac{1}{2}$ per cent. of manganese may look well and resist the tests for toughness and strength which are usually applied, and may yet contain more than $\frac{1}{4}$ per cent. of phosphorus or sulphur, or both these substances. It is only at temperatures below the freezing-point that the presence of phosphorus will make itself felt by symptoms of cold shortness, and it would therefore certainly not be advisable to put down rails of this description in cold climates.

For the construction of ordnance and other high class purposes, more than a trace of manganese in the metal is, in my opinion, decidedly objectionable. Manganese, though very efficacious in hiding impurities in the steel, is in itself an impurity inconsistent with high quality of the material produced. Its admixture with the metal is purely mechanical, and upon analysis of different portions of the same ingot it is found that its distribution is very irregular. Being more oxidizable than iron, a metal containing a considerable percentage of manganese cannot be re-heated without deterioration; is pitted by exposure to sea-water; and its strength and toughness are also found to be below those of really pure metal when subjected to crucial tests. It is important, therefore, that steel for war purposes, where high temper and great tensile strength is required, should be practically free from manganese, as well as from all other admixtures, with the sole exception of carbon. Extra mild steel, which is so remarkable for its extreme ductility, should contain in 100 parts 99·75 parts of metallic iron, and only 0·25 per cent. of all foreign substances put together.

It is for the production of these special qualities of steel that the open hearth process has come into extensive use, being employed, either wholly or partially, by many of the leading works both in this country and abroad. The total production of open-hearth steel (both the

Siemens-Martin and Siemens variety) amounted in 1877 to 275,000 tons, since which time its production has gone on increasing, notwithstanding the extreme depression which continues to prevail in the iron and steel trades.

The French Admiralty were the first to take up the subject of constructing ships of very mild steel, and the British Admiralty now use it largely in naval construction, with such results as I believe will shortly be placed before another Institution by their Chief Constructor, Mr. Barnaby.

Although I have described the open hearth process, as dealing with pig metal and ore—or, when it can be had, pig and scrap metal—my attention has been directed for many years to the accomplishment of a process, in which the ore used is put through a preparatory process of reduction and precipitation, and only a minimum quantity of pig metal is employed to impart fluidity to the mass in the melting-furnace. In my early experiments in this direction I followed the lead of Chenot and others in producing what is called spongy iron, or iron deprived of its oxygen by heating it to redness, in combination with carbonaceous material. I soon convinced myself, however, that no practical results could be obtained by this means, inasmuch as the spongy iron contains, bound up with it, the gangue of the ore, which can with difficulty be separated from the metal, and afterwards encumbers the melting-furnace with excessive slag. All the hurtful impurities contained in the ore, such as sulphur, phosphorus, arsenic, &c., remain, moreover, in the spongy iron, ; and, as regards sulphur, its quantity is much increased on account of a powerful absorbing action, exercised by the spongy iron upon the sulphurous acid contained in the flame of the furnace. It was necessary, therefore, to devise some plan by which the metallic iron could be simultaneously separated both from the ore and its impurities. This object I have succeeded in accomplishing by means of a rotating furnace, which has, however, hitherto received only a limited application. The furnace, which is represented in Fig. 3, consists of a gas producer, the air regenerator, a reversing valve, and the revolving drum. No gas regenerators are employed in this furnace, but the gas passes from the producers through an oblong channel continuously into the revolving chamber, where it is brought into contact with the heated current of air passing in from one or the other of the air regenerators. The flame thus produced rushes forward into the heating chamber, and after heating the material therein, passes back again towards the inlet side, whence the products of combustion pass through the second air regenerator and the reversing valve into the chimney stack. By this arrangement the front of the rotatory furnace is left free for access, and is provided with a charging and discharging door placed eccentrically, for the convenience of withdrawing masses or balls of iron from the furnace on a level with the lining when the furnace is stopped with the aperture in its lowest position. The lining of the furnace is made of highly aluminous or bauxite bricks covered on the inside with a certain thickness of iron oxide produced by melting hammer scale and rich ores in the furnace, which set while the

furnace is kept slowly rotating. The rotation of the furnace is effected by means of a small Brotherhood or other engine, and suitable gearing.

The *modus operandi* is as follows:—The furnace, being already lined and heated, a batch of ore mixed with fluxing and reducing materials, in a proportion depending upon the chemical constitution of the ore employed, is charged from an elevated platform in front, the rotator being stopped for this purpose with the charging orifice in its upper position. From 30 to 40 cwt. of batch is thus charged, upon which the door is closed, and the furnace chamber is made to rotate at the very slow rate of six or eight revolutions per hour. A high temperature is produced within the chamber by the combination of the gas with the highly heated air from the generator, causing the mass rapidly to become hot, whilst slowly rotating, so as to present continually new surfaces to the heat. No chemical action takes place under these circumstances until the temperature of the mass is raised to a full red heat, when reaction between the carbonaceous matter and the ore will take place, giving rise to the development of carbonic oxide, which, meeting the heated air proceeding from the regenerators, is burned, and thus adds to the heating action of the flame. When this reaction has fully set in, the supply of producer gas may be almost entirely stopped, and thus no sulphurous gas is admitted into the furnace during this critical interval. The heat now rises rapidly, and fusion of the earthy constituents of the ore occurs simultaneously with a continuance of the reducing action. In the course of an hour and a-half after starting, the charge consists of metallic iron in a more or less agglomerated condition, found on analysis to be almost chemically pure, and of a liquid mass of cinder containing the earthy constituents of the ore and other foreign matter. The rotation of the furnace is now stopped with the tapping-hole in its lowest position, and the bulk of the cinder is discharged; the tapping-hole is thereupon closed again, and the furnace made to rotate somewhat more rapidly with a view of facilitating the agglomeration of the metallic iron; by the timely introduction of a rabble, the agglomeration of the mass can be so regulated as to induce the formation of two or three balls of convenient size for handling. The balls being formed, the furnace is stopped with the large door in its lowest position, which, upon being removed, admits of the charge being withdrawn. This is effected by the introduction of tongs supported by pulleys running upon overhead rails for transferring the balls in rapid succession from the furnace to a squeezer (which has for its purpose to expel adhering cinder), and from the squeezer to the bath of such a steel melting-furnace as already described.

The great purity of the metal thus reduced from the ore, and the rapid and comparatively inexpensive nature of the reducing process, are conditions highly favourable to the production of steel of high quality by this method at reasonable cost; and it is my intention gradually to complete the open hearth process of producing steel by combining with it the mode of preparing the material to be melted just described.

Report on Tests of Mild and Hard Bars.

Mild Bars.

Strain per square inch.	Annealed.								Unannealed.							
	No. 1 Test.				No. 2 Test.				No. 3 Test.				No. 4 Test.			
	I.		II.		I.		II.		I.		II.		I.		II.	
	Elongation.	Set.	Elongation.	Set.	Elongation.	Set.	Elongation.	Set.	Elongation.	Set.	Elongation.	Set.	Elongation.	Set.	Elongation.	Set.
Tons.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3	0·015	..	0·015	..	0·015	..	0·015	..	0·015	..	0·015	..	0·015	..	0·015	
6	0·03	..	0·03	..	0·03	..	0·03	..	0·03	..	0·03	..	0·03	..	0·03	
9	0·046	..	0·046	..	0·046	..	0·046	..	0·046	..	0·046	..	0·046	..	0·046	
12	0·062	..	0·062	..	0·062	..	0·062	..	0·062	..	0·062	..	0·062	..	0·062	
15	0·078	..	0·078	..	0·078	..	0·078	..	0·078	..	0·078	..	0·078	..	0·078	
18	0·090	..	0·090	..	0·090	..	0·125	0·045	0·09	0·015	0·090	..	0·09	0·015	0·09	
18½	0·100	0·015	0·095	..	0·100	0·015	..	..	..	..	0·150	0·07	..	..	0·10	
19	..	..	0·125	0·03	..	..	..	..	..	..	..	..	..	..	0·175	0·095
							Hard Bars.									
3	0·015	..	0·015	..	0·015	..	0·015	..	0·015	..	0·015	..	0·015	..	0·015	
6	0·03	..	0·03	..	0·03	..	0·03	..	0·03	..	0·03	..	0·03	..	0·03	
9	0·046	..	0·046	..	0·046	..	0·046	..	0·046	..	0·046	..	0·046	..	0·046	
12	0·062	..	0·062	..	0·062	..	0·062	..	0·062	..	0·062	..	0·062	..	0·062	
15	0·078	..	0·078	..	0·078	..	0·078	..	0·078	..	0·078	..	0·078	..	0·078	
18	0·092	..	0·092	..	0·092	..	0·092	..	0·092	..	0·092	..	0·092	..	0·092	
21	0·108	..	0·108	..	0·108	..	0·108	..	0·110	..	0·108	..	0·110	..	0·108	
24	0·3	0·15	0·125	..	0·325	0·16	0·125	..	0·4	0·25	0·57	0·427	0·425	0·28	0·525	0·4
25	..	..	0·182	0·06	..	..	0·2	0·07								

NOTE.—In tests marked I the elongation was taken in a 5′ 0″ bar; in those marked II at a point 4′ 11″ from bottom of same bar.

What I also wish on this occasion to call attention to are certain properties of steel which are of importance in considering its applicability to engineering and military construction. We know that steel varies between very large limits in its hardness and in its ductility, but it is not so generally known that steel up to a certain point is of the same strength to resist strain when it is mild as when it is hard, and I have prepared a table of results which shows very clearly the nature of both mild steel and hard steel if compared under different strains.

Upon reference to the table it will be seen that loads from 6 to 15 tons per square inch affected all the bars equally, whether hard or soft, annealed or unannealed, and with the exception of one bar only this uniformity holds good up to 18 tons; up to this limit, the elastic elongation of all the samples was equal; but with the strain of $18\frac{1}{2}$ tons, the mild steel has become permanently elongated, whereas the harder steel shows a normal increase of elastic elongation. With the hard bars experiments were continued, and 21 tons to the square inch was applied, producing an elastic elongation ·108, which is entirely normal, and no permanent set is produced, but when 24 tons were applied, then a permanent set occurred also in the hard bars; therefore the elastic limit of the hard steel was 24 tons, whereas that of the milder steel was only 18 tons.

But there is a very peculiar circumstance connected with these elongations. If a bar of mild steel is taken from the rolls and subjected at once to a test of, say, 18 tons, it will very likely be found to show a permanent elongation, but if the same bar is first subjected to a strain of, say, 17 tons, for several hours, it will then be capable of resisting perhaps 19 or 20 tons before showing any permanent elongation. One might almost say the bar of steel can be taught to resist a higher strain without yielding permanently. Sir William Thomson has lately made some elaborate researches on this point, and perhaps he will favour the meeting with some account of them.

The question of using steel for the purposes of engineering or military construction depends a great deal upon the particular application. Mild steel has the peculiar quality of yielding to an enormous extent to strain before giving signs of rupture. Bars are tested generally to 28 tons, at which mild steel, such as is used in naval construction, generally breaks after showing an elongation of 25 per cent. The steel used in the construction of boilers, which is made still milder, will stand only a total strain of 24 tons, but will show a still greater elongation before breaking. From this we can go upwards, and produce steel that will bear a breaking strain of 50 tons, with an elongation of perhaps 12 per cent. Still harder steel shows a strength of 60 tons, and an elongation of only 7 or 8 per cent. before breaking, whilst Sir Joseph Whitworth has shown that the absolute strength of steel in the form of bars, of the proper temper, may be brought up to 90 tons per square inch, by subjecting it to a process of oil hardening; such a tensile strength is hardly exceeded by carefully tempered steel wire. Therefore we have a range of strength which

we can apply under different circumstances with great advantage. It must be borne in mind that the harder steel is apt to become brittle when suddenly cooled, and therein consists the great safety of using the milder description of steel for engineering and military purposes. With regard to this last matter I would say something before concluding, with reference to the construction of ordnance.

Years ago a great advance was made in gun manufacture by Sir William Armstrong in producing his well-known mode of construction. At that time wrought iron was the strongest material practically available for the gunmaker's use, and this was put into the strongest possible form by the construction of coiled rings, which method places the fibre of the metal in the direction of the strain. The Woolwich or Fraser system of gun construction being a modification of the Armstrong system comprises the same mode of putting iron into the condition of greatest strength; but it is time I think to enquire whether, after the recent advances made in the production of mild steel, which is a material of superior strength, tenacity, and uniformity to iron, the mode of constructing ordnance should not be modified to suit these altered circumstances.

It is important, then, to appreciate wherein consists essentially the difference between iron and mild steel.

Mild steel is a metal consisting of 99·75 per cent. of the elementary substance, iron, and only a quarter per cent. of manganese, carbon, and such impurity as phosphorus and sulphur in the smallest possible quantity; whereas wrought-iron of commerce generally consists of 96 to 97 per cent. of metallic iron and between 3 and 4 per cent. of other material, for the most part slag. Now, it seems not a very great matter that in 100 lbs. of iron there should be 3 lbs. of slag, but if we represent this proportion to our eyes we see that it is not such a very inconsiderable quantity, considering that slag is both voluminous and entirely devoid of tensile strength. I hold here two cubes, one of $4\frac{1}{2}''$ side, and the other of $2''$ side, representing, as nearly as may be, the one the metallic iron, and the other the slag, which when mixed together form wrought iron. If the slag was mixed up amongst the mass of metallic iron in an irregular way, the strength of the iron would probably be very little more than is due to that of the glassy slag, because filaments of slag might go right across; but in drawing out the iron, again and again, the little original globules of metal become elongated into strings or fibres of iron, held together by filaments of slag, and thus we get in iron a great apparent increase of strength by drawing it. But even if we draw it out to the utmost, we lose strength to the extent of the sectional area taken up by the slag, and thus get less resisting power than if the pure metal is separated from the slag in subjecting it to the melting process, when we get the maximum strength of which the metal is capable in all directions, and we have, in fact, metal of the greatest strength for moderate strains that can be obtained, as we have seen that even the hardest steel elongates as much as the mildest metal when subjected to moderate strains.

At another Institution Mr. Longridge has severely criticised the coil

system of construction, which is still followed at Woolwich, upon the ground that the stresses are not properly distributed; but whilst not agreeing with him chiefly as regards the limits to which shrinkage can be advantageously resorted to, I cannot, on the other hand, but think it is wrong in principle to use the harder and more resisting material in the inside, and the weaker material outside the gun, as is still practised at Woolwich.

Mr. Longridge says that the inner tube of the gun should be under compression, and therefore one or several layers of rings should be shrunk on with such increasing force as to bring the metal into considerable tension, in order that when the powder gas acts expansively upon the inside of the gun, the compression of the inner ring may be such as to resist the first part of the impact of the powder, and then after having come to its condition of neutrality take up its proper portion of the tensile strain. But, practically, I believe the shrinkage is not carried to any such extent, and it appears to me reasonable that it should not be, notwithstanding Mr. Longridge's argument, because if the large mass of iron he suggests to use is put under compression to the extent indicated by theory, it would inevitably crush or permanently deform the inner tube. But if the inner tube is of steel, and the outer portion of iron, a metal of less elastic range than steel, it follows that, by repeated expansive actions, the external metal will be strained beyond the limit of elasticity before the metal of greater elastic range in the interior.

Again, in firing the gun the inner metal will be expanded by the heat, which will increase the pressure exerted by the inner ring against the outer rings. This action will result in excessive strain on the outer rings tending to enlarge and loosen them, or in compressive action upon the inner tube, tending to produce the same result through crushing.

It appears, therefore, to me to be evident that in constructing a gun steel only should be used, in which the strains should, if possible, be so distributed that when the powder pressure acts, each portion should offer the same resistance to the strain. This, I think, might be effected in a very thorough manner by a process analogous to that employed by Admiral Rodman in the construction of cast-iron guns, only that cast iron is perhaps the material least adapted for the purpose. If a steel gun or a ring forming part of the same was put into a furnace, heated up to a temperature of, say, 600° C., and the inside was subjected to cooling action, while the outside was maintained at the temperature of the furnace, a distribution of stress would result which would be highly advantageous to the strength of the gun. The chilling of the inside surface of the ring or gun would cool the metal towards the inside circumference. This metal could not shrink, nor would the inner diameter of the gun diminish, because the diameter would be determined by the mass of metal still in the heated condition. The vacancies produced in the cooled metal would be filled up by the inflow of metal from the heated mass outside, resulting in equilibrium of the metal at the diameter originally due to the heated mass, and the temperature will gradually vary from, say,

100° inside to 600° outside. If the gun was afterwards taken out and allowed gradually to cool, but without stopping the cooling action from within, the whole mass would cool down to the minimum temperature. If we imagine the ring to consist of a succession of concentric cylinders, each cylinder would acquire a tensile strain due to its previous temperature, which, being a minimum on the inside and a maximum on the periphery, there would result a distribution of tension throughout the mass, being negative or compressive in the interior and more and more tensile towards the exterior. Then, when the full pressure of powder gas was active, the strain upon each portion would be equal, and the resulting strain would be opposed by the whole elastic strength of the metal. The internal portion of the tube would, with such a mode of construction, have no other function to perform than to resist the abrasion that is necessarily going on in the gun. This question is just now very much before the scientific public, and therefore I thought it well to bring before you my own view of the matter.

Before quite concluding, I would call attention to a machine which has lately been sent me from America for testing pieces of steel or iron, and after the meeting is closed I will break a test bar of mild steel, that the members may see the amount of elongation of which such a bar is capable before breaking.

The CHAIRMAN: We have some gentlemen present who are eminently qualified to assist in the elucidation of this subject, and particularly one who has been named by Dr. Siemens—I mean Sir William Thomson. Some of us have heard of the fatigue of metal, and when Dr. Siemens announced that Sir William Thomson has learned that so far from being fatigued by being subjected to a long continued strain, metal seems to get the stronger, or better able to resist it, it appeared to me a striking result.

Sir WILLIAM THOMSON: I think the information I am able to give has been rather over-estimated. My attention was first called to the subject many years ago in testing some copper wires used in the first Atlantic cable. The wire weighed about 14 grains per foot, and it began to stretch with a weight of 8 lbs. or 9 lbs. It was so very tender that it soon began to show signs of distress and permanent elongation, but by very gradually adding weights, I found I could bring up the elastic tension of that wire to 45 lbs., so that wire which first began to run down into permanent elongation with 8 lbs. would ultimately bear 45 lbs. off and on again without showing signs of further permanent elongation. That pull of 45 lbs. corresponds to the weight of about 3½ nautical miles of the wire; for 21,000 feet, or 3½ nautical miles of wire, weighed 42 lbs. That showed certainly a greater strength than I expected to find in copper wire; but that strength was only attained by very carefully adding weight, and giving time for the molecular condition consequent upon the state of strain which gave it the permanent increase of strength to be, as it were, deliberately taken by the molecules of the material. Similar results are found with iron wire. Some very soft iron wires, prepared for me by Messrs. Johnson, of Manchester, gave results somewhat similar to those of the copper wire. I found that at first a very small weight would stretch the wire, but after about 25 per cent. elongation, it bore at least five or six times the weight which originally produced a permanent elongation. I think these facts, and the more substantial information which Dr. Siemens has given us, may take away the anxiety with which testing is often regarded, especially testing steam boilers. There is a very common belief, which I consider is quite erroneous, that iron is apt to be injured by testing, and indeed the Board of Trade rule actually orders that an old boiler which is to be re-tested after having been in use is to be tested up to the working stress, but it is not ordered that it is to be tested above the working

stress, and, on the contrary, the rule enjoins that the inspector must be careful not to injure the boiler by testing. So that if the inspector puts on one pound per square inch above the stress the boiler is to stand, he does so at his own risk, and is liable to be called to account. I must say it seems to me that this rule of the Board of Trade absolutely requires revision. That men and ships are to be sent to sea with boilers that cannot be tested to double the working load is a very great anomaly. The injury depends on the force applied being greater than the material can properly bear. Now, if the material in a boiler can properly bear double the working load it is a boiler that will work, but if it cannot, it ought to be thoroughly repaired and strengthened or else broken up. It seems to me that the Board of Trade rule absolutely requires alteration, and that a steam boiler ought not to be considered to be tested at all unless it is tested to at least double the regular working load. It is quite a different thing from a test in which there is rough usage, which might cause a much heavier stress than that shown by the indicator. For instance, in the case of testing chains, nobody can say what the chain may have to bear; what you want to do is to see that the chain is free from flaws, and then let it bear the most it can. If a ship is prevented going ashore by the cable being stressed to three or four times the guaranteed breaking stress, the chain must be allowed to do its work; and as we never know the extreme force to which a chain cable is to be tested, of course no one would think of testing it to the very utmost that it is capable of bearing, lest its links should be damaged in form, or its material rendered brittle. Mr. Thurston, of the Stevens Institute of Technology, in Boston, has made some important experiments on metals which have led him to put them in two different classes, some of which do that which iron is falsely suspected of doing in ordinary criticism of testing. The ordinary criticism of testing supposes that applying a heavy strain to iron would injure it. That is true of some metals, but not of iron. Mr. Thurston finds some metals, tin being one of them, which will bear a certain weight for hours, or days, and then actually break with a less weight than that which it bore for a long time; but emphatically that is not the case with iron. Mr. Thurston's experiments prove that iron is not a metal of that class which yields after a time. Experiments by Mr. Bottomley, in the Physical Laboratory of the University of Glasgow, have been extended over long periods. We have taken some very soft iron wire, and hung on day after day, ounce by ounce, weights up to breaking weight, and the strength of the iron wire has been in some cases increased 10 per cent. above the breaking weight tested in the first instance. One of the wires broke for instance at 49 lbs., when tested quickly. Some wire of the same hank was taken and was kept for a considerable time with 45 lbs. hanging on it, and then half-pound by half-pound was added till the wire broke; and the power to resist the stress actually improved, sometimes by as much as 10 per cent., and in no case has the application and re-application, or the application and keeping on for months, as far as nine months, of a force within 1 or 2 per cent. of the breaking force, injured the whole. It has never injured it, and in some cases has decidedly increased its strength.

Mr. Barnaby: I should have been better pleased, Sir, if some of those gentlemen who are connected with the principal question of manufacture which has been brought before us this evening, namely artillery, had been called upon to speak rather than myself. As you have already heard, I shall have the opportunity shortly of saying some things of interest to those who are concerned in shipbuilding at the Iron and Steel Institute, but I should like to make just one remark with regard to what Sir William Thomson has said, and that is, that I do not quite understand what that rule of the Board of Trade is to which he refers. He must be right in what he says, but in the Royal Navy the test for boilers is always twice the working pressure. In the American Navy it is $1\frac{1}{2}$ times, but in the English Navy always twice, and I am surprised to hear of this rule. I suppose it must refer to some question of old boilers. If any gentleman here belonging to the Board of Trade could set that matter clear before we leave perhaps it would be better that it should be so explained. I think we have received a very great favour to-night in receiving from Dr. Siemens himself an account of those wonderful things by which our generation has been adorned. In ages to come I believe that our generation will be spoken of as that which produced Dr. Siemens and Mr. Bessemer.

Sir WILLIAM THOMSON: May I add one word with regard to the last part of Dr. Siemens' paper, as to the stresses in the gun and the proportions of material to adopt for resisting the stresses it will meet with in firing. I think the principle here laid down would be most valuable—a different way of producing that state of stress initially in the gun, so that you may be quite sure you have got the state of stress you desire. I hope Dr. Siemens will be able to carry it out, and actually produce a gun in which this state of stress will be realized.

Major-General YOUNGHUSBAND, R.A.: I wish, Sir, to meet an objection by Dr. Siemens as to the principle of a steel barrel in the interior of a gun while, as he rightly observes, we use the stronger metal in the interior and the weaker metal in the exterior. Dr. Siemens may not be aware that the barrel of the gun is made of steel, not for the purpose of having a stronger metal in the inside to resist the transverse strain, but because we require strength to resist the longitudinal strain. A coiled iron tube has very little longitudinal strength in itself, and therefore it is necessary to have a tube, a steel barrel, for that purpose, and also to have a hard metal for the rifled grooves, so as to be able to resist the abrasion of the studs, or whatever means may be used for giving rotation to the shot. He will know if he sees the section of any gun that steel forms a very small portion of the whole weight of the gun. It is not at all impossible, I may say not improbable, that these coiled bars used at present may be given up, though the day has not arrived yet. When we adopted that system of coiled iron bars the properties of steel were not known as they are now; we were not able to make that very mild steel which is capable of being welded, and therefore had recourse to coiled iron; and as to the construction of the gun, whatever objection may be made, we have this practical experience, that from 6,000 to 7,000 of those guns have been made, and not a single accident has happened. I believe that our guns will resist a greater strain per ton of gun than any guns that have been made. I do not say they are the very best guns that can possibly be made; I only say it, as a fact, that per ton of guns there is more strain put upon our larger guns than upon any guns that are used.

The CHAIRMAN: General Younghusband has stated, in better words than I could find, just what I was about to remark in reference to Dr. Siemens' criticism of the existing form of gun. There is another consideration which General Younghusband did not touch upon, which is, that we have the more expensive material in the smaller quantity, and that is an important consideration when we enter upon the expenditure of three millions or four millions. Steel, if applied to the making of the outside of the guns, as well as the inner tubes, would have augmented the cost of their introduction very largely, into something appalling. I do not wish to prolong the discussion further, but will express in your name to Dr. Siemens the gratification that we feel when gentlemen of his eminence will favour us with the benefit of their experience upon subjects coming home so nearly to our business and our bosoms as does the use of iron and steel.

Dr. SIEMENS: With regard to an observation made by General Younghusband, I should ask permission to say one word. I do not wish to suggest for a moment that a gun, such as is now turned out at Woolwich, is not a very excellent mechanical production; and at the time the materials that were to be used were decided upon, those were the very best materials that could be obtained. And with regard to iron, I admit the value of putting the strain in the direction of the fibre, but at the present time we have made a very considerable step forward, which I think should be taken advantage of in the construction of guns. If the coil is limited in its length, it gives, as General Younghusband says, no longitudinal strength, and the inner tube becomes a matter of much greater importance than it would necessarily be if the outside of the gun, instead of being multifarious, was solid. But there seems to be no reason why, if the outside of the gun was of steel, and the elasticity of that mass of steel was properly distributed, it should be divided, and not be of a single piece. If that was the case, the inner tube would have only one function to fulfil, that of taking the rifling; but it is most essential, I consider, that it should be as mild as is consistent with its power to resist abrasion, inasmuch as it cannot be true in principle, although it may be perfectly workable, to have the material of which the lining is composed of greater resisting power than the material surrounding this inner tube, upon which the strength of the gun

depends. The lining must necessarily be subjected to very considerable expansion through the firing itself. One fact I should like to mention, viz., that a shrinkage of 1 in 1,000 produces $11\frac{1}{2}$ to 12 tons of strain to the square inch, and an elongation of 1 in 1,000 is produced by heating the material to 130° Fahr.; therefore, if a gun is built up by shrinkage, and the inner tube afterwards heated up to 130° Fahr., the amount of fight between the inside metal and the outside must be just double. If the heating should exceed that limit, as it appears to me it would be likely to do, the strain between the inside and the outside must increase in the same ratio; and this action between the two principal portions composing the gun could only be obviated if the inner tube was of such a material as to yield absolutely to the outside strain. Therefore, it was not with a view of criticising, but rather with a view of suggesting, that I ventured to make the observations I did. I thank you very much for the kind attention you have given me this evening.

Evening Meeting.

Monday, May 5, 1879.

Admiral Sir COOPER KEY, K.C.B., F.R.S., Member of Council, in the Chair.

ON THE TURNING POWERS OF SHIPS.

By W. H. White, Assistant Constructor of the Navy.

In acceding to the request of the Council, and preparing a paper on "The Turning Powers of Ships," it seemed advisable to consider those parts of the subject which have the greatest practical interest for naval Officers, as affecting the management of existing ships of war. In these vessels the rudder is the chief source of manœuvring power, aided in many cases by the action of the propellers; and to these means of turning I shall chiefly refer. Of the various plans which have been proposed or tried for increasing the manœuvring capabilities of ships I shall say but little; of the mechanical appliances by which the movements of the helm are controlled I shall attempt no description. My principal aim will be to summarise and illustrate, in as brief and practical a manner as possible, the principles which govern the behaviour of screw steamships when turning under the action of their rudders or propellers.

The general theory of the action of the rudder was clearly stated in the earliest treatises on naval architecture published during the eighteenth century. Our present knowledge of the subject owes its chief extensions not to mathematical investigation but to direct experiment. It is customary both in the Royal Navy and in foreign navies to make a series of turning trials in connection with the steam trials of a new ship before she proceeds to sea. These preliminary or "Constructors'" trials are useful not only as affording thorough tests of the efficiency of the rudder and steering gear in a new ship; they have also furnished valuable data as to the steering qualities of ships of different classes, and have helped to correct some deductions made from purely theoretical investigations. As usually conducted, these Constructors' turning trials are made in smooth water and light winds, with the helm hard over to port or to starboard, the ship running with engines at full or half power. The observations made include—(1) a record of the time occupied in putting the helm over; (2) a

record of the times occupied in turning the half circle and full circle respectively; (3) a measurement of the diameters of the "circles" in which the ship turns. In some cases the turning trials are extended to other speeds than those corresponding to full or half power; or to angles of helm varying from "hard over" down to small angles with the keel-line; but these extensions are not common. Additional trials are also made in twin-screw ships, or ships with other kinds of duplicate propellers, to determine their behaviour when one propeller is working ahead and the other astern, or when one propeller only is at work. It need hardly be added, however, that even the fullest Constructors' trials do not furnish all or nearly all the information respecting the steering qualities of ships which Commanding Officers require. Continued experience in management, and the further trials which can be made during the service of a ship at sea, enable Commanding Officers to acquire an intimate knowledge of the turning powers of their ships under various conditions of wind, sea, speed, and helm-angle. The experience thus gained is of the greatest value, not merely as regards the management of individual ships, but in the aggregate it should form the basis of any system of naval tactics. In the Royal Navy, the regulations provide for the conduct of such turning trials in all new ships, and for the record of the results in the "Ship's Books," for the information of Officers who may succeed to the command. In the French Navy also great attention is bestowed upon similar trials of ships attached to the experimental squadrons; and a very excellent account of the method pursued will be found in Captain (now Admiral) Bourgois' "*Méthodes de Navigation et d'Expériences*," published about twelve years ago.[1]

The conduct of these steering trials lies, of course, strictly within the province of the naval Officer; but as a naval architect who has given much attention to the subject I may be permitted to indicate a few of the principal points upon which further information seems to be needed. And in order to do this as briefly as possible, I will first endeavour to sketch the circumstances attending the turning of a steamship, which is moving ahead on a straight course and with uniform speed, when the helm is put down.

It is worth notice that when a ship is moving ahead under the assumed conditions in smooth water and a dead calm, she is in *unstable equilibrium* so far as the maintenance of the straight course is concerned. That is to say, the action of a very small disturbing force will suffice to deflect her from that course. Directly the helm is put over, and an unbalanced pressure is developed on the rudder, that pressure constitutes a disturbing force, and the vessel begins to turn. Her angular motion is gradually accelerated as the helm-angle is increased, and after the helm is "hard over." After reaching its maximum rate the angular motion of the vessel becomes uniform; and thenceforward if the helm-angle and revolutions of the engines remain unaltered the vessel continues to swing round through equal angles in equal times, her centre of gravity describing a circular path, and all other points moving in concentric circles. When there is powerful

[1] Arthus-Bertrand, Editeur, Paris.

mechanical steering gear capable of putting rudders of large area over to good angles in very small times, this condition of uniform angular motion is quickly reached, probably by the time the head of the ship has swung through 360° or even a less angle from the original course. With manual power at the helm, it is stated on good authority that similar uniformity of angular motion is not obtained until the ship has completed two circuits or even more. The longer time occupied in putting the helm over with manual power accounts for this difference.

In order to determine the motion of the ship in turning it is convenient to take the following :—

(1.) The original straight course, as *line of reference*, from which to measure the angles turned through by the keel-line of the ship in specified times.

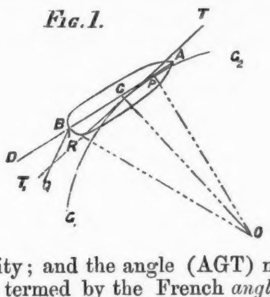
(2.) The position of the centre of the ship on the straight course at the instant when the helm begins to move over, as an *origin of co-ordinates.*

(3.) The path which the centre of gravity describes while the ship turns, as that to be determined by observation. This will practically agree with the middle of the length in most ships.

It will be obvious that if by observation we can determine the place of the centre of gravity at any instant with respect to the original course and the selected origin of co-ordinates, the path can be constructed. Also, that if the angles through which the head of the ship has turned are noted at the same times as the positions of the centre of gravity are observed, the instantaneous positions of the keel-line are found, and the instantaneous inclinations of the keel-line to the corresponding tangents to the path of the centre of gravity can be ascertained.

When the motion of rotation has become uniform, and the centre of gravity is moving in a circle, the keel-line of the ship makes a *constant angle* with the tangent to the circular path of the centre of gravity. Fig. 1 illustrates this case. A represents the bow, and B the stern of a ship. G shows the position of the centre of gravity on the keel-line AB. O is the centre of the circular paths in which G, A, and B are moving. TGT_1 is the tangent to the path (G, G_1, G_2)

Fig. 1.



of the centre of gravity; and the angle (AGT) made by the keel-line with the tangent is termed by the French *angle de dérive*, or "drift-

"angle." The value of this drift-angle varies considerably in different vessels, and in the same vessel under different conditions of speed and helm-angle. In the "Thunderer," for example, with a constant helm-angle, but with variations in the speed, the following results were obtained:—

Speed on straight.	Drift-angle.	Diameters of circles (feet).	
		Bow.	Stern.
8·2 knots.	$5\frac{3}{4}$ degrees.	1,350	1,410
9·4 ,,	$8\frac{3}{4}$,,	1,255	1,345
10·4 ,,	$9\frac{1}{4}$,,	1,240	1,340
11·14 ,,	$9\frac{1}{2}$,,	1,240	1,340

Other cases are on record where the drift-angle has been 16° or 18°. No general law has yet been formulated for the magnitude of the drift-angle; but it is generally agreed that it increases (a) with increase in speed, when helm-angle and rudder-area are constant; (b) also with increase, in rudder-area and helm-angle, speed being constant. As a consequence of the drift-angle, the bow and stern of the ship revolve in circles of different diameters; and in the above table the results for the "Thunderer" furnish an illustration of the fact. Furthermore, in any given time the head of the ship must have turned through an angle from the original course, which exceeds the angle turned through by the centre of gravity by a quantity equal to the drift-angle.

Turning again to Fig. 1, let P be the foot of a perpendicular let fall from the centre O upon the middle line of the ship (AB). Then to an observer on board the ship, P will appear to be the "pivot-point" about which the angular motion of the ship is being performed at each instant; for it will be seen that the keel-line AB coincides with the tangent to the path of the point P, which is not true of any other point on the keel-line. In other words, at P there is no drift-angle; whereas for every other point in the keel-line there is a drift-angle, the value of which is easily determined when that for the centre of gravity G and the radius OG have been determined. In the case of the "Thunderer," the pivot-point P varied from 67 to 103 feet before the centre of gravity; or from about 80 to 40 feet from the stern. As the speed and drift-angle increased, so the pivot-point moved forward. It need hardly be added, that the point O is the true centre of the motion of the ship in turning; although P appears to an observer on board to be the pivot on which the ship turns during the time she has uniform angular velocity.

Another circumstance requiring notice in connection with the uniform turning motion now under consideration, is the *loss of speed* sustained by the ship when turning, as compared with her speed on the straight course from which she began to turn. Taking several cases

where this loss has been carefully measured, I find that the speed of advance on the circular path has only been *seven-tenths* or *eight-tenths* of the speed on the straight. It is often supposed that this loss of speed is chiefly due to the "drag" of the rudder. Anyone who investigates the matter will become convinced that the rudder-pressure has little to do with this considerable decrease in speed; the real cause is to be found in the drift-angle. Glancing once more at Fig. 1, it will be evident that, at each instant, while the propelling force is delivered along or parallel to the keel-line, the actual motion of the vessel in turning is not directly ahead, but sideways. In fact, the motion bears a considerable resemblance to the motion of a ship sailing on a wind; and there is a considerable pressure developed on the side of the bow most distant from the centre O. This pressure not merely checks the speed of the ship, but exercises a considerable turning effect, assisting the pressure on the rudder. The importance of this assistance will appear more clearly when it is considered that owing to the rotary motion of the vessel while turning, the flow of water at the stern is different, even in screw steamers, from that which would take place before the angular motion became considerable. In fact, the *effective* helm-angle becomes considerably reduced from the angle RBD, Fig. 1, which the rudder makes with the keel-line AB, produced. So far as I am aware, we have no exact data for estimating the amount of this reduction; but French experimentalists assert that it approaches to equality with the drift-angle for the rudder-axis B. If OB is joined, and BQ drawn perpendicular to it, then the effective helm-angle, according to the French rule, should be taken as approximately equal to RBQ, and not to DBR, or a reduction of at least *one-half* from the angle made with the keel-line, even in single-screw ships. Approximately the pressure on the rudder may be expressed as a function of the speed of the ship, and the *sine* of the effective angle of helm; so that the loss of rudder-pressure consequent upon such a reduction in the effective angle as is asserted to take place will be very considerable. Apart from exact measures of the reduction, there can be no question as to the fact; and it is one of the matters upon which further experiments might well be made in English ships. With the assistance of a dynamometer to register the strains on the tiller-end when the helm is first put over, and after the turning motion has become uniform, it would be an easy matter to discover the variations in the effective helm-angle, if the revolutions of the engines and speed of the ship were also observed.

In concluding these remarks on uniform angular motion, it may be well to refer to the *heeling*, which accompanies turning. The forces which tend to produce heeling are as follows:—

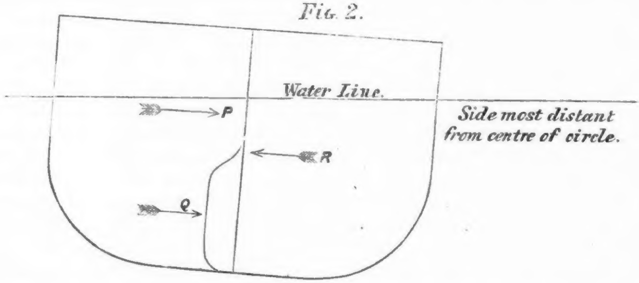
1. The centrifugal force acting outwards through the centre of gravity of the ship, and tending to make her heel away from the centre of the circle.

2. The lateral component of the rudder-pressure, acting through the centre of pressure of the rudder at some depth below the centre of gravity of the ship, and tending to make her heel inwards towards the centre of the circle.

3. The lateral component of the fluid resistance on the outer side of the ship, which equals in magnitude the resultant of the centrifugal force and the rudder-pressure, and acts through the centre of lateral resistance.

Fig. 2 shows the distribution of these forces in the "Thunderer," determined from the turning trials made at Portland. Here again it

Fig. 2.



is common to find the rudder-pressure credited with the heeling effect; whereas it may, in most cases, be neglected in comparison with the centrifugal force. A fair approximation to the angle of heel for a ship in turning is given by the following equation:—

$$\sin\,\theta = \frac{1}{32} \times \frac{d}{m} \times \frac{v^2}{\mathrm{R}},$$

where θ = angle of heel,
v = speed of ship in feet per second,
R = radius of circle turned (in feet),
m = "metacentric height"—height of transverse metacentric above centre of gravity,
d = distance of centre of gravity above centre of lateral resistance.

In the "Thunderer," the centre of lateral resistance was found to be from ·43 to ·49 of the mean draught below the water-line; probably a fair approximation for war ships of ordinary form would be from ·45 to ·5 of the mean draught. From the foregoing equation it will be seen that—

The angle of heel varies (1) Directly as the *square of the speed* of ship;
(2) Inversely with the *metacentric height;*
(3) Inversely with the *radius* of the circle.

Hence it is obvious that ships of high speed, fitted with steam steering gear, capable of turning on circles of comparatively small diameter, are those in which heeling may be expected to be greatest. Moderate values of the metacentric height further tend to increase the heeling. If the speed be *doubled*, the angle of heel will be about *quadrupled*, if

the radius of the circle turned and the metacentric height remain constant. In order to maintain a certain angle of heel under these altered conditions of speed, the metacentric height would also have to be quadrupled; but such an increase in stiffness is clearly undesirable even if it were practicable. The following figures may be interesting:—

	Speed on straight.	Diameter of circle.	Draught.		Metacentric height.	Angle of heel.	
	knots.	feet.	feet.	in.	feet.		
"Thunderer"	8·2	1,340	26	3	3·12	0°	52′
	9·4	1,250	26	1		1	11
	10·4	1,240	26	1		1	14
"Tourville" (French) ..	15	2,030	..		..	3	30
"Victorieuse" (French).	10	1,290	..		..	2	0

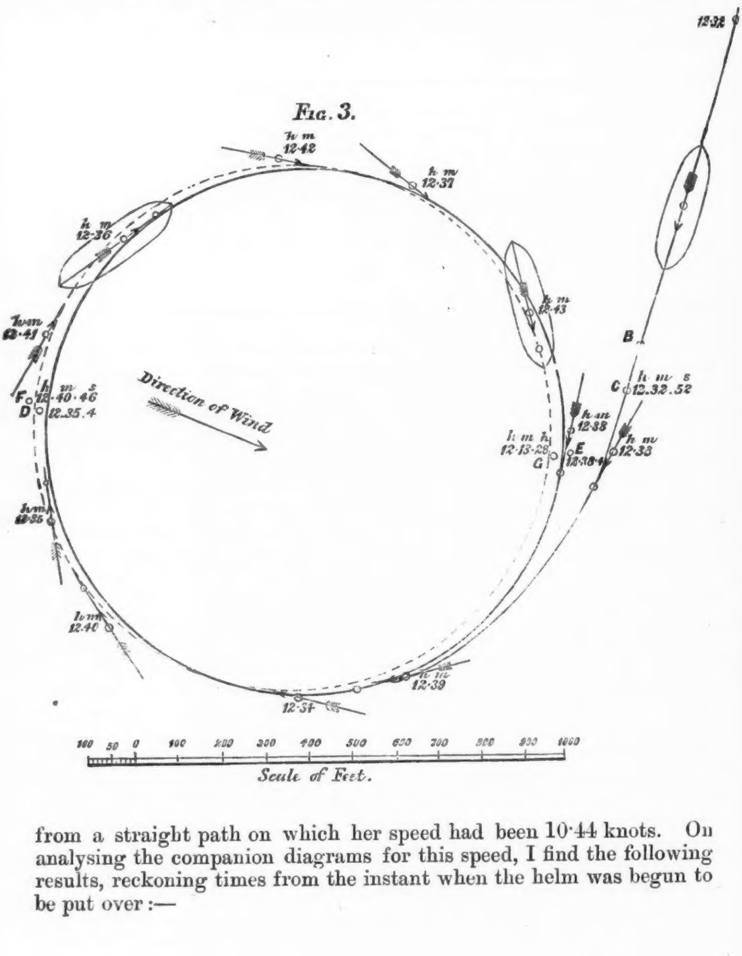
It is important to notice that in taking observations of the angle of heel for a ship in turning, allowance must be made for the effect of the centrifugal force upon the indications of pendulums or clinometers. The error of indication is always in excess, and the correction is very easily made when the diameter of the circle and time of turning have been ascertained.

In treating at some length the case of a ship turning uniformly in a circular path, I have endeavoured to clear the ground somewhat for the discussion of the more difficult case, which has far more practical importance, where the angular motion of the ship is not uniform, and the path of her centre of gravity is not circular. When the helm of a ship is put down, and she begins to turn away from a straight course, it is interesting to know (1) whether she will readily answer her helm; (2) what will be the path traversed by her centre of gravity; (3) what will be the rate of growth of her drift-angle; (4) what will be her gradual loss of speed as compared with her speed on the straight course. Probably the most important pieces of information in relation to naval tactics will be as follows:—1. The place of the centre of gravity of the ship when her head has swung through 90° from her original course; that place being fixed (in the manner previously described) with reference to the original course and the position of the centre of gravity thereon at the instant the helm begins to move over. 2. The speed of the ship when she has turned through the first 90°. 3. The time occupied in turning 90°. 4. The time and space required to reverse the course, turning through 180°.

It is singular to find on inquiry how meagre is the information recorded on the first three of these points. I can discover no case except that of the "Thunderer," in which the actual path traversed by the centre of gravity of the ship has been determined from the instant the helm was put down to the time when the turning motion had become uniform. All the facts as to these trials have been published in the report of the "Inflexible" Committee, and they deserve

the careful study of all naval Officers. I do not propose to reproduce them here, but to use a few of the results only for purposes of illustration. Fig. 3 shows the course traversed by that ship, when turning

FIG. 3.



from a straight path on which her speed had been 10·44 knots. On analysing the companion diagrams for this speed, I find the following results, reckoning times from the instant when the helm was begun to be put over :—

	Time.	At end of time.	
		Speed of ship.	Angular velocity per second.
	Seconds.	knots.	
To put helm over 31°	19	10·4	0° 20′
To turn ship's head 45°	56	9·25	1 18
" " 90	89	8·3	1 18
" " 135	123	7·75	1 15
" " 180	159	7·5	1 12
" " 360	320	7·14	1 6¾

At 360° the turning motion had become practically uniform. The conditions here traced for the "Thunderer" are representative for all steamships when turning under the action of their rudders from a straight course on which they were originally moving ahead. There will, of course, be differences in different ships as regards the times occupied in putting the helm down, or in passing through the various changes which precede the attainment of uniform angular velocity, as well as in the value of that velocity. But in all cases as a ship turns from her straight course, she will be subjected to angular acceleration, her drift-angle will gradually increase, she will heel more and more, and her speed will decrease. But by degrees these transitory conditions will pass away, if the helm is kept at a constant angle, and the engines at a nearly constant speed, and ultimately a state of uniform motion and steady heel will be reached such as I have previously attempted to describe.

Purely theoretical investigation does not enable one to lay down the path of the centre of gravity of a ship from her straight course to the position occupied when the head has turned through 90°; nor are we much better off for the remaining part of her path until the turning becomes uniform. The greatest difficulty in framing the equations of motion arises from the uncertain state of our knowledge respecting the resistance offered by the water to the motion of the ship in turning. Hence it becomes necessary that the problem should be attacked by actual experiment, and careful observations made, which would enable the path traversed to be subsequently plotted. French writers assert that the curve traversed by a ship from the place where her helm is put over to her place when she has turned through 180°, can be treated without serious error as a circle touching the original course. The perpendicular distance from the place of the centre of gravity when the head has turned through 180°, to the original course, is termed by the French the "diameter of evolution." Captain Colomb has proposed to call it the "tactical diameter." Unfortunately the "Thunderer" experiments show that the French assumption as to the character of the curve is only a rough approximation; and apart from those experiments it is obvious that for different ships the cha-

racter of the curve is likely to vary. Among the controlling circumstances which chiefly need attention are—

1. The area of the rudder, the maximum angle to which the helm can be put over, the rapidity with which it can be put hard over.

2. The speed of the ship or that of her propeller, as well as other causes influencing the flow of water relatively to the rudder, and the consequent development of an unbalanced pressure on the rudder, which exercises a turning effect on the ship.

3. The moment of inertia of the ship taken about a vertical axis passing through the centre of gravity of the ship.

4. The moment of the resistance offered by the water to the lateral, rotary, and endwise motions of the ship.

It would be out of place for me to give any explanation of the causes which produce and determine the magnitude of the pressure on the rudder, since the matter is fully discussed in text books of naval architecture. Moreover, the ship comes into the hands of her Commanding Officer furnished with her rudder and steering gear, which have been tested in the Constructor's trials. Experience may suggest improvements, of course; but, as a rule, the changes made are not great, and consequently in the management of the ship an Officer can take advantage only of variations in the helm-angle below a certain fixed maximum, and of variations in speed or direction of motion. It is generally agreed that—

1. Other things being equal, the turning effect of a rudder increases with an increase in the helm-angle up to 40° or 45° with the keel-line.

2. Other things being equal, the rate of acquisition of angular velocity, or the rapidity with which a ship turns, increases as the time occupied in putting the helm hard over is diminished.

Hereafter I shall mention a case or two illustrating the effect of putting the helm over more quickly upon the turning of ships; but as illustrations of the advantages of large helm-angles, I may quote at once a few figures from actual trials. Admiral Sir Cooper Key found that the "Delight" gunboat behaved as under, when the helm-angle alone was varied :—

Helm-angle.	Time of turning full circle.	Diameter of circle.
10°	3′ 52″	615 feet
20	3 18	405 ,,
30	2 57	275 ,,
40	2 47	205 ,,

Admiral Halsted, in the trials conducted with the floating battery "Terror," obtained the following results :—

Helm-angle.	Time of turning full circle.
10°	6′ 19″
20	5 28
30	5 1
40	4 42

Lieutenant Coumes, of the French Navy, gives the following results for the iron-clad corvette "Victorieuse," for an initial speed of about $12\frac{1}{2}$ knots:—

Helm-angle.	Time of turning full circle.	Diameter of circle.
7°	9′ 48″	1,060 metres.
14	6 50	933 ,,
21	5 50	750 ,,
27	5 20	572 ,,
$32\frac{1}{2}$	5 20	475 ,,

Respecting the remaining circumstances enumerated above as affecting the turning motion, a very few remarks will suffice. In arranging the longitudinal distribution of the weights in a new ship, the naval architect cannot be governed by consideration of the effect which the *moment of inertia* has upon the turning qualities. But it is well known that if the weights are carried far away towards the ends of a ship, and her moment of inertia is great, she will be *slow* to *answer her helm*, as compared with a ship of similar form and equal displacement, having the weights more concentrated towards the middle of the length. Again, as regards the effect of fluid resistance, which depends largely upon the under-water form, no designer can be much influenced in deciding upon the form of a ship by considerations relating to resistance to turning. He has to consider ease and economy of propulsion before these minor matters, and can only make changes of a subordinate character, such as cutting up the fore-foot, or raising the after end of the keel, in order to diminish somewhat the resistance to turning. On the other hand there are cases, and particularly in ships of shallow draught and full form, where difficulties arise from the fact that they experience so little resistance in turning. For while resistance opposes change in the course of a ship, it also enables her to be easily kept on a new course when her head has been brought round to it. Probably I speak the experience of many naval men in saying that the ships most difficult of management are vessels of great inertia and shallow draught. At first such vessels may be slow to answer their helms, but when once the angular motion has been established it is most difficult to check it because of the comparatively small resistance. The Russian circular ships are reported to be very difficult to manage: and clearly the principal reason for their uncertain behaviour must be found in the association of a large amount of inertia with a very small resistance to rotation, due chiefly to skin-friction. If the inertia and resistance are both small, as happens in shallow-draught gunboats, the vessels quickly acquire angular motion after the helm is put over, but "sheer" off sideways from the course on which their keel-line points because of the small amount of their lateral resistance. These are a few among many of the illustrations that might be given of the fact that some classes of ships have their turning powers affected by their special features, modifications in which are inadmissible. In such cases careful management is of the greatest importance, and enlarged experience leads to improved behaviour and greater certainty in control.

Although the true character of the path traversed by a ship in turning has been determined in very few cases, it is known that it is more or less spiral up to the time that uniform angular velocity is reached. This departure from a true circle is of the character indicated in Fig. 3, and it places the ship when she has turned through 360° and is again pointing in the original direction, somewhat to port or starboard of the original course, according as the ship is turning to port or starboard. The space occupied in turning through 180° and reversing the course has been termed the tactical diameter (*diamètre d'évolution*); it considerably exceeds the diameter of the circular orbit in which the ship turns after her motion has become uniform, or "final "diameter" (*diamètre de gyration*). The reason is obvious; in the earlier part of the turning motion of the ship she is acquiring angular motion, that is to say, is subject to angular acceleration, and the curvature of her path is less pronounced than it is in the subsequent stages. It may be interesting to illustrate the ratio of the tactical and final diameters by a few figures drawn from actual trials:—

	Helm-angle.	Speed on straight.	Diameters.	
			Tactical.	Final.
			feet.	feet.
"Thunderer" (English)....	31°	8·2 knots.	1,405	1,340
		9·4 "	1,320	1,250
		10·4 "	1,320	1,240
"Victorieuse" (French)....	33°	10·0 "	1,440	1,230

At present the published information on the ratio of tactical to final diameters is very limited: it is a subject to which further experiments may well be devoted. But for all practical purposes the determination of the tactical diameter is the more important. In the Constructors' turning trials the diameter of the circle, as usually determined, is practically the tactical diameter, as will appear from the description given hereafter. With manual power and ordinary rudders the diameter of the circle for large ships has been found to vary between six and eight times the length of the ships; for small ships wherein manual power suffices to put the helm over rapidly and the speed is low, the diameter falls to three or five times the length. For swift torpedo-boats with manual power only at the helm and very small angles of helm, the diameter of the circle for full speed has reached about twelve times the length, and for half speed about four or six times the length. With manual power and *balanced* rudders the diameter for large ships has been reduced to four or five times the length; and nearly equal results have been obtained with ordinary rudders worked by steam or hydraulic steering gear. About three times the length is the minimum diameter yet obtained in large ships turning under the action of their rudders. These figures apply chiefly

to full-speed trials; but it appears that differences of speed do not greatly affect the diameter of the circles, although they do affect the time of turning, so long as the time occupied in putting the helm hard over is nearly constant. For the same ship with the same angle of helm, and about the same time occupied in putting the helm over, the time occupied in turning the circle appears to vary nearly inversely as the speed. The time occupied in putting the helm hard over considerably affects the time of turning, and also influences the diameter of the circle. In the case of one of Her Majesty's ships where the conditions remained almost unchanged, except that a steam steering engine was fitted, and the time occupied in putting the helm hard over was reduced from 90 seconds to 20 seconds, the time occupied in turning the circle was reduced from $8\frac{1}{2}$ minutes to a little over 7 minutes, and the diameter of the circle was reduced from 970 yards to 885 yards. Before steam steering engines became common in the Royal Navy, balanced rudders furnished the best means of putting a large rudder area over quickly to a large angle, and the "Bellerophon," "Hercules," "Monarch," and other vessels so fitted performed admirably in turning under steam. But now that mechanical steering appliances are available, ordinary rudders, hinged at their fore edge, are once more preferred, because they are simpler and less liable to derangement than balanced rudders, besides being more suitable for use in ships having sail as well as steam power.

The determination of the tactical diameter is an important matter, but it does not furnish a complete or sufficient account of the space necessary for a ship to reverse her course; for it gives only a measurement at right angles to the original course—which may be termed the "transfer" of the ship—and affords no measure of her "advance" in the direction of her original course. Taking the case of the "Thunderer" (Fig. 3) it appears that, reckoning from the instant when the helm began to move over, the ship *advanced* about 1,000 feet in the direction of her straight course before her head had swung through 90°, and was *transferred* (at right angles to her course) about 700 feet. When her head had turned through 180° and the course was reversed, the *advance* had been reduced to 520 feet, while the *transfer* (or tactical diameter) had increased to 1,320 feet. It is most important to ascertain the advance and transfer for the 90° position; the necessary observations are easily made, and I shall not occupy space with a description of any one among the many methods that might be used.

Passing from these general considerations, I will now endeavour to sketch briefly the methods adopted for measuring the diameters of the circles turned by ships on their Constructor's trials.

The first is that commonly used in trials of Her Majesty's ships; it was introduced about fifteen years ago by Mr. Martin, Chief Constructor of Pembroke Dockyard, and is illustrated by Fig. 4.

At any assigned place in the length of the ship two vertical battens, b, b, are fixed in the same transverse plane, and an observer is stationed at the position fixed by one of these battens. A second observer is stationed at B, at a certain longitudinal distance, l, from

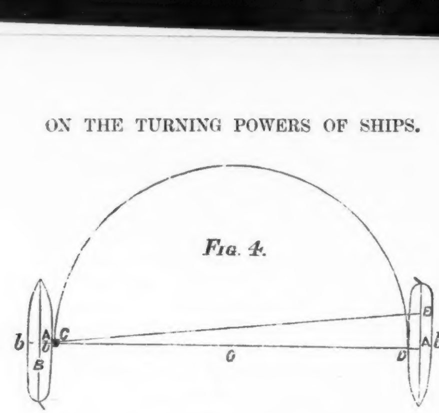


Fig. 4.

the first observer, and this second observer has to operate a very simple instrument for measuring angles, which is shown on a larger scale in Fig. 5. The zero-line of this measuring instrument is made

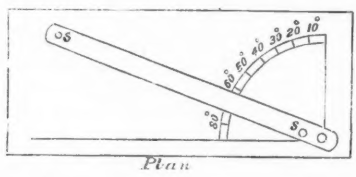


Fig. 5.

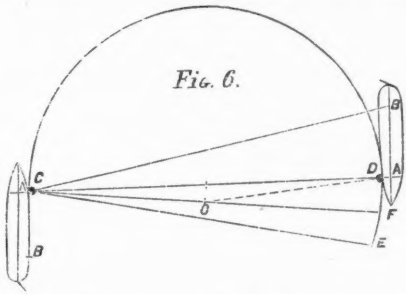
to coincide with, or be parallel to, the middle line of the ship. When the helm begins to move over, a box, C, is thrown overboard from the station b, at which the fixed battens are placed. After the ship has turned through such an angle that the line joining the two fixed battens again bears upon the box, C, a signal is made to the second observer, who instantly notes the angle (ABC) which the line of sight to the box, C, makes with the zero-line of his measuring instrument; let this angle be termed α. Then a simple trigonometrical ratio gives—

$$\text{Diameter of circle} = l. \tan. \alpha,$$

if the semicircle is supposed to be completed when the angle α is measured. This is a good practical method for smooth water and a calm. Obviously it takes no account of a possible drift of the box, and it assumes the omission of the "drift-angle" for the ship, on the supposition that the semicircle of rotation is not completed until the line joining CD is a diameter of the circle. As a matter of fact, owing to the creation of the drift-angle, the head of the ship will have turned through 180° *before* her centre of gravity has traversed so large an arc in its path. The amount of this possible error in most large ships is not great, and for ascertaining the diameter of the circle simply the

plan is a good one. It may be added, that since the diameter determined is for the points in the ship at which the fixed battens are placed, by fixing them first at the bow and next transposing them to the stern it would be possible to ascertain the diameters of the respective circles for the bow and stern, and thence to determine the drift-angle approximately.

Lieutenant Coumes, of the French Navy, has recently published an extension of the English method, which deserves to be widely known. It is illustrated in Fig. 6. He assumes the path of the ship from the



straight course to a little beyond the place where she has turned through 180° to be an arc of a circle. At the position C, on Fig. 6, a buoy is dropped overboard abreast the fixed battens, just as is done in the English plan. At the position marked D the head of the ship has swung through 180° and the line joining the two fixed battens bears upon the box at C. An observer stationed at B, at a known distance from the fixed battens, notes the value of the angle, ABC (α), at that instant, and simultaneously a second box, D, is dropped overboard. The ship moves on to a position E a little beyond D, and the observer stationed at the fixed battens notes the angle, EDC (β), which the two boxes, C and D, then subtend. These are all the observations needed. Suppose O to be the centre of the circular path, join CO and produce it to meet the circle at F, also join DF. Then the angle, DFC, is equal to β, being in the same segment, and the angle, CDF, being in a semicircle, is a right angle. Hence—

$$\text{Diameter of circle} = \text{CD} \times \text{cosec.}\ \beta$$
$$\text{,,} \qquad \text{,,} \quad = l.\ \text{tan.}\ \alpha\ \text{cosec.}\ \beta.$$

Further, it will be seen that the drift-angle, (δ), equals the angle, CDO, which is equal to DCO, and is therefore the complement of β.

The maximum correction produced by substituting Lieutenant Coumes' method for Mr. Martin's in estimating the "tactical "diameter" is expressed by the product of the radius into the versed sine of the angle of drift, or algebraically—

$$\text{Error} = \text{radius} \times \text{versine}\ \delta,$$

where δ varies between 10° and 20° and versine δ varies between ·015

and ·06. This correction is evidently of little importance in most cases.

Another plan, which has been extensively used in estimating the diameter of the circles turned, is to tow a patent log astern and note the distance it registers while the ship turns through 360°. This registered distance is afterwards treated as the circumference of a circle, and the diameter is obtained by a simple calculation. Opinions are divided as to the trustworthiness of this plan. I do not pretend to be in a position to decide the matter, but feel confident that the chances of error must be greater than in the geometrical methods above described. Even with the best logs available towed behind a vessel moving at a varying speed and turning, there must be great danger that their indications will vary with differences of speed or will be affected with the wake of the vessel. The French have made comparative trials of the geometrical method and of log-measurement, the result being unfavourable to the latter.

Still another plan, well adapted for small vessels, is that devised by Sir Cooper Key and used in the turning trials of Her Majesty's gunboat "Delight," conducted at Devonport in 1863. The register of a Massey's patent sounding machine was removed from the lead and attached to a long staff. At the commencement of a circle the register was immersed, when the circle was completed it was immediately raised. The distance registered was read off, and this was treated as the circumference of the circle traversed.

In the French squadrons of 1864–66 the turning trials were conducted differently from any of the foregoing methods. Captain Bourgois gives the particulars in his pamphlet previously noticed; it may be briefly described as follows:—One ship of the squadron was anchored, and the vessel whose movements were to be recorded turned about the stationary vessel. Two observers were stationed at a known distance apart on board the moving vessel. At frequent and regular intervals of time these observers noted simultaneously and recorded the angular elevation of a mast-head in the anchored vessel. The height of this mast-head above the water being known, this series of observations gave the distances of the anchored ship from each observer at each time of observation. Meanwhile observers stationed on board the anchored vessel took frequent and simultaneous observations of the angular elevations and bearings of a mast-head in the ship that was turning. And further, other observers on board the moving ship noted at frequent intervals the angles subtended by a mast in the anchored ship with some fixed and distant object. These observations would have sufficed to determine the path traversed by the ship from the time her helm was put down; but it is a remarkable fact that the important motions of the ships through the first 90° of rotation were designedly neglected, and the observations were begun only when approximately uniform circular motion had been attained. On the other hand, it is in these records one finds attention first given to the importance of determining the drift-angle.

The French appear to attach great importance to the determination of the tactical diameter corresponding to various revolutions of the

screw and various helm-angles for individual ships. I leave naval Officers to say what this knowledge may be worth in its bearing upon the movements of the ships composing a squadron; but it is obvious that if the ships are of various sizes and types, combined movements under steam can be performed with greater uniformity if the Admiral has this kind of information for all the ships under his command. Perhaps it may be as well to add that the plan which has been sometimes adopted for estimating the diameter of the circle turned by counting the revolutions of the engines, and thence deducing the speed, is liable to lead into serious error. Owing to the drift-angle the speed corresponding to a given number of revolutions is much less when a ship is turning then it is when she is on a straight course. In the "Thunderer," for example, a speed of 10·4 knots was obtained with 65 revolutions, whereas on the circle 59 revolutions only gave a speed of 7·14 knots.

In concluding these remarks on methods of recording the behaviour of ships when turning I may be permitted to add that in the trials with the "Thunderer" the method of procedure embraced many of the foregoing principles, and enabled a most searching check and counter-check to be put upon the observations. Any Officer familiar with nautical observations will find no difficulty in arranging his own programme should he decide to accurately determine the path of his ship in turning under certain assumed conditions. But he can only derive benefit from a study of what was done in the "Thunderer," the report of the trials of that ship containing the most thorough information yet published on this subject.

It is impossible to discuss the "Turning Powers of Ships," even in the outline to which I am compelled to confine myself in the present paper, without referring to the manœuvring power given to a ship by *duplicate propellers*, and more especially by twin-screws. Twin-screws are now almost universally adopted in the most powerful war-ships, and their efficiency as propellers is well established. But they have the further advantage of enabling a vessel, by reversing one of her screws while the other drives her ahead, to turn in a very small circle —almost in her own length. The rate of turning under these circumstances is often slow, but the power of giving rotation to a ship practically destitute of headway and independently of the rudder is of great value. Twin-screws are, of course, associated with rudders, and no one at all conversant with the subject would propose to trust to twin-screws alone for manœuvring purposes. They are really only valuable auxiliaries to the rudder, and in no sense rivals to it.

Beside twin-screws there are disconnecting paddles and water-jets which come under the category of duplicate propellers, giving manœuvring powers to ships. Paddles are, however, out of the question in men-of-war. From water-jets considerable manœuvring power was expected, but the trials of the jet-propelled "Waterwitch" in competition with the twin-screw "Viper" showed the distinct inferiority in this respect of the jet-propellers. Moreover, it is evident that so far as the trials of water-jets have yet been carried they are decidedly inferior to twin-screws as propellers. Under these circumstances

it appears reasonable to adopt twin-screws, as the remaining arguments urged in support of the use of water-jets seem comparatively unimportant. I express this opinion after careful consideration of what has been said respecting the enormous pumping power obtained from the turbines, and of the little risk of serious damage being sustained by jet-propellers. But it would be out of place to say more on these subjects in this paper.

The "Waterwitch" and "Viper" are of nearly the same length, and were tried at as nearly as possible the same displacement, draught, and speed. "The "Waterwitch" is a "double-bowed ship," the intention being that she should be equally capable of steaming with either end foremost; she has a rudder at each end, but on the trials only that at the after end was used. The "Viper" is a vessel of very different form, her stern being formed with two dead-woods, each of which carries a rudder. She gains upon the "Waterwitch," by having this additional rudder, but loses very seriously in having a tunnel-shaped cavity between the dead-woods which interferes both with her propulsion and with her manœuvring. When steaming full speed ahead with rudders hard over, the times for turning the circle were—"Viper," 3 minutes 17 seconds; "Waterwitch," 4 minutes 10 seconds. With one screw reversed and the other turning ahead, helm hard over, the "Viper" took 3 minutes 6 seconds to turn the circle; while the "Waterwitch" under similar conditions—with jets delivered in opposite directions—took $6\frac{1}{2}$ minutes to turn the circle. Even allowing for the additional rudder in the "Viper" these results speak strongly in favour of the twin-screws. I am informed by gentlemen who attended these trials that there were evidences in the "Waterwitch" of a reaction of the jets against the sides of the vessel adjacent to the outlets, which reaction had a moment opposing the turning moment due to the thrusts of the jets. And on *à priori* grounds such a check to the turning motion seems probable, and may become considerable.

It may be interesting to add, with regard to the turning effect of twin-screws when working in opposite directions, that in deep-draught ships the time occupied in turning is usually greater than the time for turning the circle with both screws working ahead at full speed; whereas for shallow-draught ships the corresponding difference in time is small. For example, in the "Captain," the time for circle at full speed ahead was 5 minutes 24 seconds; that for circle with screws working in opposite directions, 6 minutes 52 seconds. In the shallow-draught gunboats of the "Medina" class, on the other hand, the full speed turning trial gave about 3 minutes 6 seconds for the circle, and with screws working in opposite directions the time was only 3 minutes 13 seconds. It will be obvious that in the shallow-draught ships the ratio of the moment of resistance to rotation to the turning moment of the screws is much less than the corresponding ratio for deep-draught ships.

Trustworthy data are much needed respecting one feature in the steerage of twin-screw ships. It is well known that with one screw only at work a small angle of helm will keep a twin-screw ship on a

straight course; and this is a proof of the moderate turning-moment obtained with twin-screws working in opposite directions. But I have searched unsuccessfully for records of exact experiments determining what angle of helm suffices to balance one of twin-screws working alone; and I shall be much indebted to gentlemen who may be good enough to give me the needed information. The facts to be noted are very few and simple: viz. (1) the revolutions of the screw; (2) the speed of the ship; (3) the angle of helm required to keep the vessel straight.

When I speak of the moderate turning effect of twin-screws, it will be understood that I have in mind the corresponding effect of even a small rudder at a small angle, in a ship steaming at full speed ahead. The normal pressure on such a rudder will be considerable when compared with the thrust of a screw; but the greatest gain for the rudder-pressure is the *leverage* with which it acts. Roughly speaking this leverage is equal to the product—*half length of ship* × *cosine of helm-angle;* whereas for the twin-screws the corresponding leverage is only about equal to the transverse distance between the screw-shafts, or less than one-half the extreme breadth of the ship. It must not be forgotten, however, that for the rudder to act most efficiently, a ship must have good headway; whereas in the twin-screw ship there is a possibility of turning with very little motion ahead.

The steering effect of a single screw, which has the greatest practical interest, is that in ships where the rudder is placed abaft the screw. It is well known that in such cases, if the screw be turned ahead or astern when a vessel is at rest, the impact of the screw-race upon the rudder will give steerage power before the vessel has acquired sensible headway. By this means it is possible to slew a single-screw ship round in a very limited space in calm weather, although the operation is a very tedious one. But there is another steering effect of a single screw, independent of the rudder, with which sailors are familiar: I mean the effect which produces a turning motion in a ship of which the helm is kept amidships, while the screw revolves. The principal causes of this turning motion are (1) the difference of the transverse thrust on the blades of the screw in the upper and lower halves of their orbit; (2) the difference in the lateral pressures, due to the momentum of the streams delivered by the upper and lower blades of the screw upon the sternpost and body of the ship. The ordinary result in ships of the Royal Navy is that with *well-immersed* screws, the head of the ship turns in the same direction as the *upper* blades of the screws move; but that with screws which are near the surface, or which sweep above the surface, the contrary holds good, and the head of the ship turns in the direction in which the lower blades are moving. I am aware that there are exceptions to these rules, but think they generally hold good for ships moving *ahead*. When the screws are turning astern, the conditions are altered materially, but I cannot pause to discuss this division of the subject. Hereafter I shall again refer to it briefly.

Various attempts have been made to derive steering power from *single screws* by mechanical arrangements enabling the screws to

deliver their thrust at an angle with the keel-line. One of the first of these was that proposed by Mr. Curtis, and tried at Devonport some years ago. The screw was carried in a frame, hinged like a rudder, which could be put over to a considerable angle with the keel. A suitable joint was provided so that the fixed shaft could communicate rotary motion to the screw in any position. The plan succeeded well so far as steering power was concerned, but it was felt that this power was purchased at too great risk of disablement of the propelling apparatus for large ships.

Recently a most ingenious plan for effecting the same object has been patented by an American, Colonel Mallory, who has devised a method for rotating the screw through a complete circle, and meanwhile keeping the main engines running continuously in one direction. A boat fitted with the Mallory propeller (Plate XXIII) can be turned almost on her centre, stopped very rapidly, and kept thoroughly under control by the action of the screw alone, no rudder being fitted. No trials on a large scale have been made, but it is clear that difficulties which can be readily surmounted in a boat may become very formidable in a large ship with great engine power and high speed. Risks which may be run in boats and small vessels may also become too great when applied to seagoing ships of war. There are mechanical difficulties connected with the Mallory propeller if used in large vessels, to which I need not here draw attention, my object being simply to indicate the lines along which recent inventions have proceeded.

Since mechanical steering gear and twin-screws have come into general use for large war-ships, their manœuvring powers have been so greatly increased that few trials have been made of plans for further improvements. But in connection with the fast torpedo-boats which have grown rapidly into importance, many trials of novel or improved steering appliances have been made which would of themselves form the subject of a most interesting paper. These torpedo-boats, on account of their great engine power, high speed, and shallow draught, are found to sweep over a comparatively large space in turning. Their designers have not failed to remark the disadvantages resulting from their comparative unhandiness, nor have they been slow to attempt a remedy. In the Herreshoff torpedo-boat, built in America, and purchased for the Royal Navy, both the screw and the rudder are placed under the bottom of the boat, and the results are very satisfactory both as regards propulsion and steering. Going either ahead or astern, the boat can be turned in about three times her length, and when steaming ahead at full speed, can be stopped in a very small distance. In a large vessel of considerable draught, I need hardly say, neither the screw nor the rudder could be placed similarly below the keel.

Messrs. Thorneycroft have tried various plans in their torpedo-boats, placing the rudders before the screws in earlier boats, and subsequently placing the rudders abaft the screws, with very beneficial results so far as the steering is concerned. Their latest device is a revival of one of the oldest methods, if not the oldest method of steering, by means of a paddle or scull placed at one end of the boat, and operated by a most ingenious mechanical arrangement. This

THE MALLORY PROPELLER.

Fig. 1.

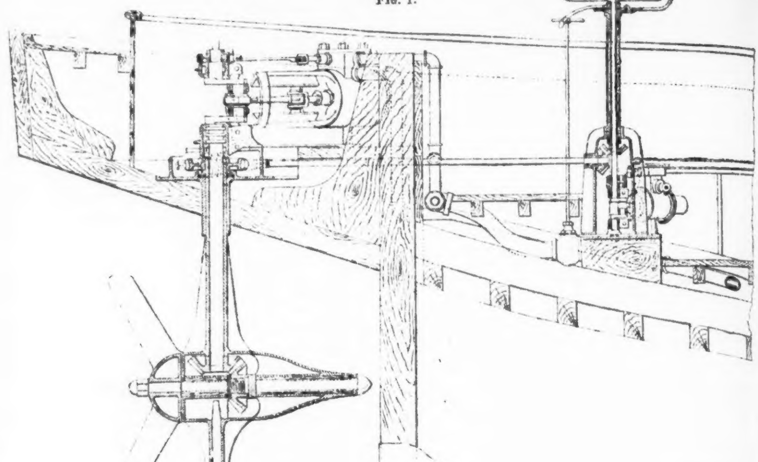
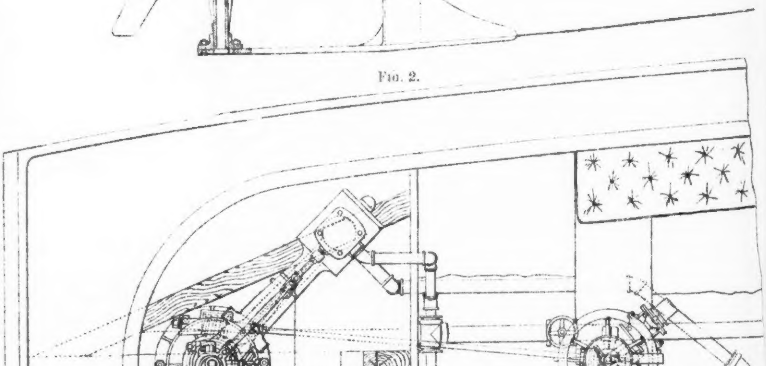


Fig. 2.



plan is patented, and answers admirably in the trial boat to which it has been fitted. Its greatest merit appears to consist in the power it gives to slew the boat round without headway, and to keep her pointing at an enemy even when the main engines are at rest. In a torpedo-boat this power seems of the greatest importance. Messrs. Yarrow have also availed themselves of an old idea, applying it to torpedo-boats in a very ingenious manner. Besides the ordinary rudder at the stern, they have fitted a bow-rudder which can be drawn up into a recess in the boat when not required, or dropped below the bottom and put over to a considerable angle with the keel-line when it is to be used for steering. On trial it has been found a valuable auxiliary to the stern-rudder when the boat is moving ahead, and a very efficient rudder when the boat is moving astern.

I may be permitted to remark in passing, that the trials of both Messrs. Yarrow's boats and the Herreshoff boat have fully confirmed the opinion respecting bow-rudders held by naval architects previous to the trials. In order that a bow-rudder may be effective in steering a ship which is moving ahead, there must be a free flow for the water past the aft side of the rudder, without any necessity for its impact upon the hull of the ship. When a bow-rudder is hung, as is usual, at the after edge to the stem of a ship, this condition is obviously unfulfilled. On the other hand, a properly arranged balanced bow-rudder, or a bow-rudder placed below the hull, will fulfil the conditions. Bow-rudders are, however, chiefly useful in ships designed for service in rivers or narrow waters, where it is frequently convenient to steam with the stern foremost instead of turning.

Auxiliary rudders of many kinds have been proposed and tried. In the Museum of Naval Models at the Royal Naval College, Greenwich, a good collection of these plans may be seen, and it shows how frequently an invention is re-invented by persons who have the same object in view, but are working in ignorance of what has been done by their predecessors. I have only space to allude to the most recent and most successful trials of auxiliary rudders made in the "Comus" class of the Royal Navy. These vessels have an ordinary rudder at the stern, and an auxiliary rudder fitted in a recess in the after part of the hull below the screw shaft. This auxiliary rudder has side-plates fitted at some distance from the body, on the plan proposed by M. Jöessel, of the French Navy. On trial it was found to answer fairly, keeping the vessel under control, although its effect did not compare favourably with that of the main rudder; nor was this anticipated, since the rudder is fitted as an auxiliary only for use when the main rudder is disabled in action.

The steerage of a screw steamship having engines reversed, while she has either *headway* or *sternway*, supposing her to be fitted only with an ordinary rudder at the stern, is a subject for experimental inquiry rather than for mathematical investigation. It is easy to see what causes are in operation tending to control the behaviour of the vessel; but these causes are so conflicting and variable as to make any general statement of little value. The following extract from the Report of the Committee appointed by the British Association "to

THE MALLORY PROPELLER.

Fig. 1.

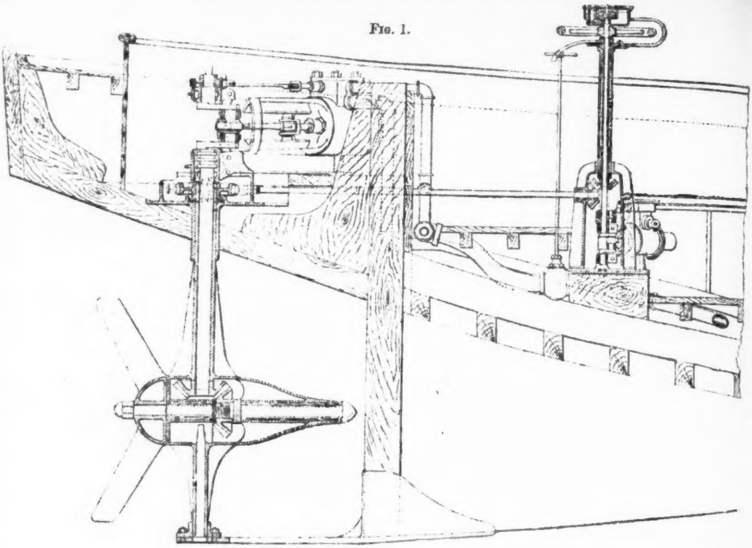


Fig. 2.

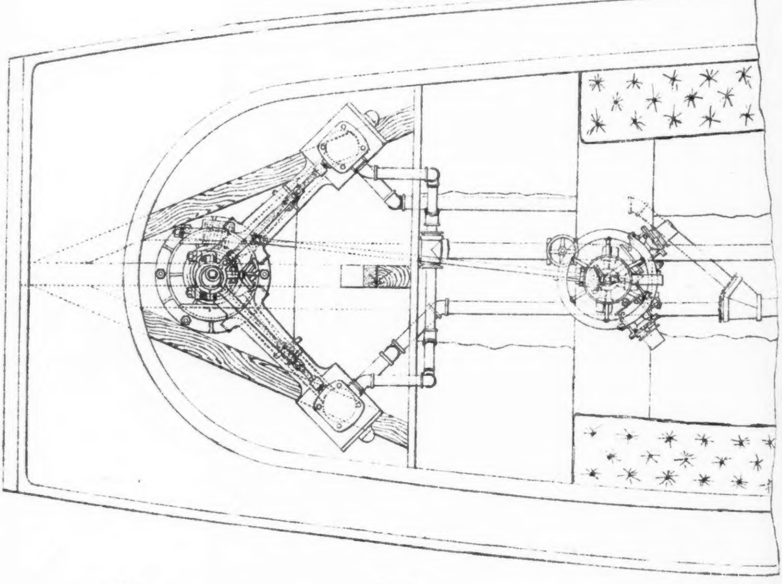


Fig. 3.

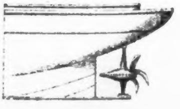


Fig. 4.

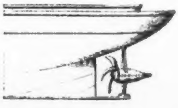


Fig. 5.

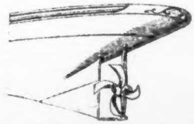


Fig 1 is a vertical longitudinal section of the stern portion of a ship, showing the apparatus; Fig. 2 being a plan. Fig. 3 shows the position of the propeller when the vessel is going ahead, and Fig. 4 when she is moving astern; whilst Fig. 5 shows

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"investigate the effect of Propellers on the Steering of Vessels," may be read with interest, as it represents the conclusions reached after a considerable number of experiments had been made by Professor Osborne Reynolds and other members of the Committee :—

"It appears both from the experiments made by the Committee, "and from other evidence, that the distance required by a screw "steamer to bring herself to rest from full speed by the reversal of "her screw, is independent, or nearly so, of the power of her engines, "but depends upon the size and build of the ship, and generally lies "between four and six times the ship's length. It is to be borne in "mind that it is to the behaviour of the ship during this interval, that "the following remarks apply.

"The main point the Committee have had in view has been to "ascertain how far the reversing of the screw in order to stop a ship "did, or did not, interfere with the action of the rudder during the "interval of stopping; and it is as regards this point that the most "important light has been thrown on the question of handling ships. "It is found an invariable rule that, during the interval in which a "ship is stopping herself by the reversal of her screw, the rudder pro- "duces none of its usual effects to turn the ship; but that under "these circumstances the effect of the rudder, such as it is, is to turn "the ship in the opposite direction from that in which she would "turn if the screw were going ahead. The magnitude of this reverse "effect of the rudder is always feeble, and is different for different "ships, and even for the same ship under different conditions of "lading.

"It also appears from the trials that, owing to the feeble influence "of the rudder over the ship during the interval in which she is "stopping, she is then at the mercy of any other influences that may "act upon her. Thus the wind, which always exerts an influence to "turn the stern (or forward end) of the ship into the wind, but which "influence is usually well under control of the rudder, may, when the "screw is reversed, become paramount, and cause the ship to turn in "a direction the very opposite of that which is desired. Also the "reversed screw will exercise an influence which increases as the "ship's way is diminished to turn the ship to starboard or port, "according as it is right or left handed: this being particularly the "case when the ships are in light draught.

"These several influences, the reversed effect of the rudder, the "effect of the wind, and the action of the screw, will determine the "course the ship takes during the interval of stopping. They may "balance, in which case the ship will go straight on: or any one of "three may predominate and determine the course of the ship. The "utmost effect of these influences when they all act in conjunction, as "when the screw is right handed, the helm starboarded, and the "wind on the starboard side, is small as compared with the influence "of the rudder as it acts when the ship is steaming ahead. In no "instance has a ship tried by the Committee been able to turn with "the screw reversed on a circle of less than double the radius of that "on which she would turn when steaming ahead. So that even if

"those in charge could govern the direction in which the ship will "turn while stopping she turns but slowly, whereas in point of fact "those in charge have little or no control over this direction, and "unless they are exceptionally well acquainted with their ship, they "will be unable even to predict the direction."

There is much in these conclusions which has been well known for many years to men engaged in handling screw steamers; and trials were made in the "Great Britain" to determine the effect of the screw-race upon the steerage. But no one can look through the Reports of the Committee from which the above quotation is made, without feeling that their experiments are very valuable and deserving of being carefully studied by all Officers in command of screw steamships. Differences of opinion which exist as to the wisdom of some of the recommendations for avoiding collisions made by the Committee, will not prevent any one interested in the subject from acknowledging the great merits of the work done by the Committee, or at its request.

Throughout this paper it has been assumed that the ship's manœuvring capabilities are ascertained in smooth water and in a calm or light breeze. These are the conditions most suitable for exact experiments and comparison; but I need hardly say that such trials do not represent the conditions of actual service. It would be idle to attempt any discussion of the influence which the wind and sea have upon the turning powers of ships, since that influence is so variable. But, on the other hand, it must be remembered that the principles previously laid down for turning in smooth water hold good also in a seaway; only the effects of the rudder, of the inertia, and resistance are then supplemented by the effects of wind and sea. This branch of the subject is, in fact, one of seamanship, and not one to be discussed by the naval architect.

The general conclusions to which my study of the subject of this paper has led me may be briefly summarised as follows:—

(1.) On the whole the ordinary rudder, hung at the stern of a ship, has not been equalled for manœuvring purposes when a ship has *headway*.

(2.) When associated with steam or hydraulic steering gear the ordinary rudder hinged at its forward edge to the sternpost is to be preferred to all other kinds of rudders. Balanced rudders are chiefly useful, if mechanical steering gear is not available, in large ships.

(3.) Twin-screws furnish the best combination of economical propulsion with manœuvring power which has yet been produced.

(4.) The various inventions hitherto tried for rendering the thrust of a single propeller available for manœuvring purposes involve risks and drawbacks too serious to be encountered in large ships, although the contrary may be true in small craft.

(5.) Bow-rudders are chiefly useful to assist steerage in ships moving astern. Balanced or "drop" bow-rudders are to be preferred for use when ships are moving ahead.

(6.) It is desirable that further and careful observations should be made of the actual behaviour of ships when turning at various speeds

and with different helm-angles. Accurate plottings of the path traversed while the head of the ship swings through the first 90° from her original course are especially needed.

I must apologise for the many omissions which have necessarily been made in the treatment of this important subject. My aim has been to have regard chiefly to that which is practically interesting and important, and I shall be amply repaid for the labour involved in preparing this paper if any of the suggestions made for further experiments should be carried out in practice by Officers into whose hands the paper may come.

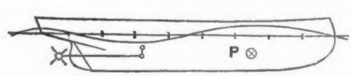
Captain LONG, R.N.: After the kind manner in which Mr. White has referred to me, I feel compelled to rise to offer some observations on his paper. It is not for me to compliment Mr. White, but I cannot rise without expressing my sincere gratitude to him, which I believe is shared by every Officer in Her Majesty's Navy, for the trouble he has taken to convey food to what I may call our hungry minds. Mr. White in his book states that the action of the screw on the rudder was known in 1845. Now I have been 20 years in sea-going ships, and I have never heard that fact mentioned. That shows either that I must be very negligent in learning my duty or that the Service does not offer that means of obtaining information which it ought to afford. That I consider a matter of very great importance to this country. We are often told that theory is pernicious, but the fact is, the experience of a naval Officer in peace time is so totally different to what it would be in war time, that I do not think any argument would be founded upon it. During peace time we are supposed to take the greatest possible care of our vessels, to avoid the slightest risk, and to go at the most economical speed. The expense involved prevents many of the real circumstances of war from coming before a naval Officer unless he takes the trouble personally to seek them. As to the action of twin-screws on the rudder, I have heard from the Staff Commander of the "Thunderer," that the "Thunderer" sometimes appears to be lost control of by her helm—she appears to move suddenly, and to require the whole helm to prevent her going right off; and he attributes it to the screws turning outwards. I am not sufficiently acquainted with the subject to tell whether that is practically correct; but I should like to ask Mr. White whether he knows any reason why they should turn outwards in preference to turning inwards. Perhaps also Mr. White can tell us whether we are likely to obtain any information of the probable effect in reducing a ship's turning power that would be produced by a watertight compartment, or two watertight compartments getting full at the extremes, because in action that is very likely to happen. Perhaps her two bow compartments would be full, and in order to estimate what you ought to do under those circumstances, it would be desirable to know beforehand, with some degree of approximation, what reduction of turning power that would cause. I have copied from the British Association Report the experiments with the "Hankow," which are very interesting, and I will hand them in, in case the Council should think proper to append them to the paper. They are corroborative of all that Mr. White has said. I may mention that the azimuth of the ship's head having been noted by the standard Admiralty compass, the arcs turned through could not be taken as being strictly accurate. With reference to Mr. White's observation concerning merchant steamers, I have in that case averaged the angular velocity of the ship when she had obtained the uniform stage, and that was 27′ per second as against 1° 18′ of the "Thunderer." She is a vessel of 3,594 tons, 389 ft. long, and 42 ft. beam, with a draught of water 24 ft. 8 in. forward, and 23 ft. 8 in. aft. That shows that this merchant steamer, which is no doubt a very representative vessel of trading steamers, only turned when she was under her full helm at one-third the speed of the "Thunderer." I was reading M. Coumes' method and also hearing Mr. White's very interesting lectures at Greenwich, that called my attention to the subject of plotting curves, and when I applied M. Coumes' method to the "Thunderer's," I could not quite get it out. I found the angle Beta always came so close to 90°, that it did not seem to me to be of any use.

What we want to know when we turn a ship is, starting from the point where we give the order to the helm, where we shall be after we have turned through 90° and 180°. We do not care much about anything else, the other parts of it belong more to the naval architects. Of course the difficulty is how to know that you turn through a certain angle. If you are near land, you can take a distant object at right angles to your course, allowing for parallax, and say, When that is ahead, I shall have turned through 90°; but the convenient times for doing these things are generally when you are a long way off land, and under those circumstances I should strongly recommend Sir William Thomson's compass. I should not like to recommend it entirely on my own responsibility; but I have Sir William Thomson's own words for it that that compass when compensated would register accurate azimuths through a circle, and I also have the authority of the Staff Commander of the "Thunderer," who has had that compass on board 18 months; he speaks very highly of it, and strongly advocates its adoption by all men-of-war. If you had not such a compass, you might get the angles with an ordinary compass brass arc if furnished with a shadow pin standing vertically up in the centre of the compass, so that the shadow is thrown on the arc, and by that you could tell the angle you turn through. Of course that would not be available in cloudy weather, so that I think Sir William Thomson's, on the whole, is the best one. Admiral Bourgois, who has taken great interest in these subjects, says that a table of turning powers is no less necessary to a ram than a range table to a gun. That is a very important thing, and I could not conclude these remarks better than by saying that it appears to me in every ship there should be a curve of the diameters by the circles obtained at constant speeds, and various helm-angles, and also at constant helm-angles and various speeds. If these two things were made for every ship we should have a vast amount of information that we do not possess at present.

Mr. Scott Russell: I am sure I express the feeling of all who have listened to this very admirable paper when I say that we are greatly indebted to the author for the luminous manner in which he has put a great deal of very valuable information together. On these points I do not think I can contribute anything to the value of his paper. There are, perhaps, one or two points on which I rather differ from him, and perhaps it would be best that I should merely state what those points are. I think he has drawn our attention very admirably towards what he calls the "drift" as an element in the steering. I wish to confirm what he has said upon that subject, by very large experience of my own. Having had to build ships that were to turn in extremely small spaces at high velocities, I made all experiments necessary to guide me on that subject, and I very soon made that discovery, which is now incorporated in these papers, namely, that with high velocities, the turning-point is not at all the centre of gravity of the ship; the turning-point is a point a great way in front of the midship section, and that is a subject difficult to understand. I do not say that you cannot make a clear exposition of the causes of it, but I will venture to mention one or two cases, because they show us how we are to get the better of these difficulties. When a ship is going rapidly through the water, in proportion to the rapidity of her motion she raises up a wave of displaced water on each side of her bow, and that wave is a plus or positive wave rising above the level for the whole length of the bow of a well-constructed ship. On the other hand, in the rear or run of the ship, the water, instead of being heaped up, goes down like that [Diagram], but this depends on circumstances and speed. When you attempt to revolve the ship, you have, resisting the turning of the bow, the whole energy of the water which you are striking. Here, then, is a strong reason why the pivoting of your ship, independent of drift altogether, arising purely from difference of pressure, should be very different indeed from a vessel turning round its centre of gravity.

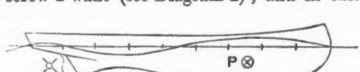
Then I go to the next point. I think Mr. White has omitted another element in the turning of the ship, which element is the effect of centrifugal force. I do not put much value on that centrifugal force, excepting under certain circumstances, but there is another power which he did not tell us of, and which, I dare say, he is quite well acquainted with (but it is a serious element), a power of turning the vessel and making her heel, arising from quite other elements. Suppose this [pointing] to be the vertical line in the run of the ship abaft; suppose the rudder

put hard over on one side, and suppose the shape of the ship abaft to be the ordinary stern of a ship. Then when he puts the rudder hard over, Mr. White knows very well that it immediately raises a great heap of water on one side to the height due to the velocity with which she is going; and he knows as well as I do that at ten miles an hour, that is a height of 16 feet. That height is of course instigated by the form of the ship, and the angle of helm; but there still remains a portion of that 16 feet, and the rudder turned on one side causes the water at that side to rise to a certain height, which certain height depends on the angle of the rudder, on the speed of the ship, and on the form of the run of the ship. Therefore, there is here a very strong effect upon the vessel which, when she turns round in a certain direction, makes her heel over so [showing]. That, I think, is an element not to be despised. You may ask, What conclusions do you draw from this? Well, I think that you are obliged to draw several practical conclusions from it. Before I had studied this subject, when I was called upon to make rapidly turning vessels, I was induced, as I dare say many of you have been induced, to think that by cutting off the dead wood of the extremely fine part of the bow, which you can generally do without inconvenience, you would get a much better turning power. I found I got, not a *much* better turning power, but only a *little* better turning power, and the reason is the one I have mentioned, that if the vessel pivoted round very near the stern, then anything you cut off the bow would greatly assist it in turning; but if, on the contrary, the turning-point is much nearer the bow than the stern, then in that proportion you get very much greater advantage from what you cut off. Therefore, when I had to build very fast vessels, to turn rapidly under difficult circumstances, I was compelled (which I regretted) to cut away the whole of the dead wood abaft. (See Diagram 1). By that means I got the power wanted, and



In Fig. 1, the pivoting centre P, is shown as resulting from the different conditions of the bow water and the run water in an ordinary well shapen fast ship turning rapidly at high speed; and the screw is shown in the right place for that form and speed of ship.

thus removed the pivoting point around which the ship turned, and also removed the part of the ship which had to move round most rapidly, but I got a vessel I very much disliked. There are certain difficulties connected with screw propelling which make me dislike that, but if I am compelled to do it, if the steering power and the rapid turning power is the most important point in the vessel, then I show you how I do it: I simply send the shaft right through the rudder, and then put the screw on behind. No doubt the screw is much below what you may call the keel of the ship; but I get rid of all the after keel of the ship. I put here exactly what depth I want, and then I put *here* what depth of rudder I want, and *there* what depth of screw I want (see Diagram 2); and in this manner, supposing

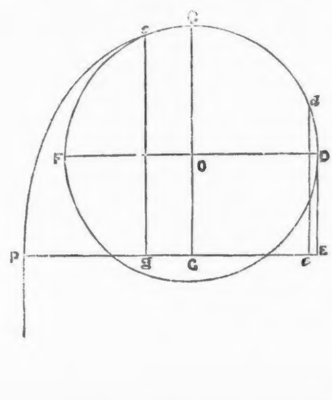


In Fig. 2, the same vessel is shown, as it was successfully improved in form, so as to gain increased power and quickness of turning.

the water to be as I have shown it here, rising up in a wave behind, and supposing this screw to be judiciously placed, it ought to be very nearly in the centre of the culminating point of this wave in the run. Then you have here a mode of propelling a ship which gives you the greatest possible turning power, without, as

far as I know, any sacrifice of any good sea-going quality, or of any speed. I think those are the only points on which I can suggest any difference of opinion from the admirable paper we have just heard, and I thought it my duty merely to contribute that slight difference of view on the matter which may exist between Mr. White and myself.

Captain P. H. COLOMB, R.N.: There are two kinds of papers that we usually have in this Institution; one, of the speculative kind, and sometimes those papers are exceedingly useful. At other times, and less often, we have papers of the solid kind which will be referred to for the next twenty years, as I have no doubt this paper of the lecturer's will be. In my humble opinion there are few questions connected with naval warfare, and I will say also with modern sea traffic, more important than that with which the lecturer has dealt. So long as 120 or 130 ships go to the bottom every year from collision, so long will it be important to know what the turning powers of ships are, because at the base of the laws on which the avoidance of collision is to rest, lie the actual turning powers of the ship. For ourselves in the Navy, I think that the remark of Admiral Bourgois, quoted by Captain Long, is exceedingly to the point. We have introduced into naval warfare a new weapon—the ram. We acknowledge that it is almost the first weapon of future naval warfare, and yet as to the use of that weapon we are comparatively in ignorance, and it is by such papers as this that we are to learn how to use it. Any person undertaking to study the question of the turning powers of ships will be met at once with the difficulty there is in getting data. We have to recollect that this study has grown up since, I may say, about 1863, and I think our gallant Chairman is the very first person in Europe who devoted real attention to it, and who produced real facts. We have had to-night reference to the facts obtained by Sir Cooper Key in 1863; and I can say for my own part, having gone over most of the ground which the lecturer has gone over, that I still go back to the record of those experiments of Sir Cooper Key's for data. There is very little indeed in this paper which I should not be prepared to confirm myself, from my own independent investigations. There are some minor points in which I can hardly say that I differ from him, but I think it would be proper to put them forward. They are possibly theories, but they are theories which have struck me as bearing a certain modicum of truth amongst them. I think there is no doubt but that the character of the curve of every steam-ship is that which the lecturer has given us; that is to say, it is a spiral gradually turning into a circle. The lecturer has put forward, very nearly, the points that naval Officers want. They want the position of the ship when she has turned 90°, and the position of the ship measured from the origin of the ordinates when she has turned 180°. I am glad that Mr. White accepts some of my terms, because I think that in a question of this kind it is important to use definitions which everybody will understand. In this curve, PCDF, we can see certain elements. There is first the "tactical diameter," PE, that is to say, the



distance between the two courses when the original course is reversed. At the point C, a curve of 90° will have been described, and PG and GC are the co-ordinates of that point. GC will then be the "advance," and PG the "transfer." Those two lines are evidently the "elements" giving you the position of the ship at C. When the ship has turned 180° and continues her course, we get the tactical diameter. Then, supposing O to be the centre of her final circle, you get the line FD as the "final diameter." So far as space is concerned, those would be the elements of the curve, and if we had for every ship the "transfer" and the "advance" in turning through 90°, and the "tactical diameter," we should have, I think, quite sufficient to satisfy us for some years to come. But there is not a ship afloat, with the exception of the "Thunderer," of which we possess those elements. These are all elements connected with space; and you want besides the elements of time. You want to know the time it takes for the ship to pass from P to C, and the time it takes to pass from C to D, and by consequence the time it takes to pass from P to D. If you had those five elements, three of space and two of time, you would have pretty nearly all that we should require. But you are met by a difficulty when you come to investigate the question: there have been many different methods of measurement. Even at the present time, I believe that if we were to investigate closely, we should find that sometimes with our own ships there would be differences of measurement at different points which would to a certain extent mar any comparative results between them; and when you come to compare French ships with English ships you find in the same way that you cannot get the accurate elements for forming a just comparison. Practically, unless you know how the measurements were made, it is not of very much use to compare the figures which are given as to the turning-powers of any two ships. The "drift-angle" the lecturer adverted to first, and quite rightly, because it is the important part of the whole business. We are assuming in this diagram that there is no drift-angle, that is to say, that when the centre of gravity of the ship has turned through a path of 90° angular distance the line of keel has also altered 90°, but we know now that, owing to the drift-angle, this will take place some time before the centre of gravity reaches the point C. The time at which the final drift-angle is reached is unfortunately not quite satisfactorily made out in the "Thunderer" diagrams; but supposing it is 10° at the point *c*, the ship will have turned through 90° there, though the centre of gravity has only described an arc of 80°. The consequence is you will get an advance and a transfer so much less than if there were no drift-angle, and you will get the advance in relation to the transfer increased; that is to say, in turning 90° with a drift-angle your spirality is greater than it would be without a drift-angle. The drift-angle would chiefly affect the transfer; it reduces it in the ratio of the *sine* of the drift-angle. It does not reduce the tactical diameter to the same extent, acting on it in the ratio of the versine of the angle, and this may be one of the reasons why we have not noticed it. We have measured either the final diameter, or the tactical diameter, and neither are much affected. If we had been in the habit of measuring the "advance" we should have detected the drift-angle before this.

Passing from this we come to the next point, the loss of speed. It is curious that M. Lewal, of the French Navy, calculated that there must be a drift-angle, from the fact of the observed loss of speed. He found a measure of loss of speed of ships in turning, and came to the conclusion that the rudder itself could never produce that amount of loss; and he thereupon actually calculated the drift-angles of French ships from their loss of speed in turning, and those calculations were in the main corroborated by subsequent experiments. But the loss of speed itself does not prove a drift-angle. You can easily see that, if you recollect that the power employed is the same throughout, a certain number of revolutions of the engines. If you employ some of these revolutions in turning the ship, it is obvious that you must take them away from propulsive effect. You cannot have the same amount of propulsion through the water when some of the power of the engines is absorbed in turning the ship. But M. Lewal found that this would not account for all the loss of speed, and from the excess of loss he calculated the drift-angle. In the paper Mr. White has given the loss of speed at from two-tenths to three-tenths. That is so, I think, in the "Thunderer," but in Sir Cooper Key's experiments with the gunboat it was very much more. The loss of speed was

45 per cent. with a 30° helm-angle, and 63 per cent. with a 45° helm-angle. These figures are perhaps not quite correct, but still I think you may certainly take it that you will find ships with a very much greater loss of speed than from two-tenths to three-tenths. Wanting these elements for your purpose, the next point is, I think, some common and simple method of measurement, and I do not know that there is any better method than to take what was done in the "Thunderer." If you take three observers in your ship, and have two graduated arcs, such as are figured there from Mr. Martin's plan, with a given base between them, one towards the stern and the other towards the bow of the ship, and if you have besides a dumb compass set off from the middle line of the ship, then if you drop a buoy or a target (it would be very conveniently done after target practice) and pass it, or steer towards it at any distance, so that you may make sure of turning round it in your circle, if then you take observations of it with your two graduated arcs, those observations being timed by the observer at the dumb compass, who is either taking bearings of the buoy or else at a distant object; if you get a pair of observations at the point P, another pair of observations when the ship has turned through 90°, and another when the ship has turned through 180°, you will get the actual position, by calculation, of the line of keel at those three points. Having that, it seems to me that you will, knowing what we know of the nature of the curve, be able to plot out, quite sufficiently for all your present tactical purposes, the elements of your curve.

The lecturer dwelt on the question of "heeling." That was more by the way, than from its tactical importance; but I think, recollecting that we must constantly prepare broadsides for firing when the ship is on the straight, and on an even keel, and that you must fire them when the ship is under the influence of her helm, it becomes of very considerable importance that we should know what heel we should have to expect at differences of speed with different helm-angles, and lay the guns accordingly. I do not think this is a matter by the way at all. I think it is quite an important element in the problem.

There is a curious anomaly in the "Thunderer's" turning circles which I have not observed in any other, but which I must presume obtains in all twin-screws. All the authorities, so far as I know, are agreed that, though the difference may be small, the diameter of the final circle becomes smaller as the speed is reduced. There is not a great difference between the diameters, but if you take a final circle at a very high speed, and a final circle at a very low speed, the last diameter will be somewhat smaller than the other; but in the "Thunderer" you get exactly the opposite result. The final diameters in the "Thunderer" go on increasing as the speed decreases. If you refer to the "Inflexible" report you see the apparent cause of it. For some reason, the differences of revolutions in the two screws vary according to the speed. At the high speed the difference of revolution between the inner and outer screw is very considerable, so that you have not only the action of the rudder, but the action of the difference between the outer and the inner screw assisting to turn the ship. When you come down to a low speed, at 8·2 knots, the difference between the revolution of the screws is very small, consequently you are then depending to turn the ship on the rudder solely, without any assistance from the screws. It is a curious fact, and deserves to be noted. It bears out perhaps what we have always been accustomed to regard as the fact, namely, that in single screws the final diameter becomes slightly smaller as you decrease the speed. We have heard it stated that Sir William Thomson's compass might be used in these trials. I have the greatest possible respect for Sir William Thomson's compass. I came home with one in a Peninsular and Oriental ship from Point de Galle. I watched its behaviour very closely, and was never so satisfied with a compass in my life. I never saw a compass so beautifully steady. I am told, however, that it was actually put under trial for the "Thunderer" experiments, and was found to be too sluggish, and failed.

The Chairman: That was just at the first; it succeeded thoroughly afterwards.

Captain Colomb: Now there is a very curious point that the lecturer has adverted to, which I want to bring before you specially—that is, as to bow rudders. He puts it that the whole loss of the effect of the bow rudder is due

to the fact that there is a reactionary pressure; that whatever pressure is brought on the right surface of the bow rudder is also thrown upon the wrong surface of the bow, and so the action is destroyed. But I think, recollecting that in the "Thunderer" herself the pivoting point in some cases was only one-seventh of the distance from forward to aft, that is to say, that the lever arm from the pivoting point to the bow was only one-sixth of what it was from the pivoting point to the stern, I think it follows that whatever rudder you put at the bow it is almost impossible it should have much effect. But now Mr. White brings up against that view this peculiar experiment, the effect of dropping a bow rudder below the keel in one of the torpedo boats. It appears on the surface as if it would directly prove Mr. White's case, but I doubt it. Suppose that in Mr. White's diagram (Fig. 1) you have a line of keel of a ship turning on a circle whose centre was at O. You have first of all certain pressures along the outside of the ship balancing exactly the tendency to fly from the centre, and you may put the whole of those forces as represented by equal and opposite forces acting through the pivoting point. Now, what have you besides? As the ship is turned round in that way you have the pressure of the water against her starboard bow, and you have also the pressure of the water against her port quarter. That is to say, in the first instance you have the pressures balancing the centrifugal force, and then you have the pressures offering resistance to rotation, which are overcome by the effect of the engines and rudder. But now, if you say that she is pivoting on a point very much before the centre of gravity, you have a couple formed by the centrifugal force through the centre of gravity, and the resultant of the pressures on the outside of the ship. Now if you by any means increase the surface before this pivoting point, you immediately transfer that point further forward; you increase the length of the arm of your couple, and you increase the moment of rudder power and the velocity of the centre of gravity. I cannot help suspecting that without moving the rudder spoken of from its midship position you would still find that you had increased your drift-angle, and so got greater turning powers, not due to the action of this as a rudder, but due to its action as transferring the point of resistance further forward, and to increasing the arm of the couple. That is about the only point at which I feel myself at disagreement with Mr. White, and I must frankly own when I began to face these questions mathematically I very soon got out of my depth, but at the same time I cannot help thinking that there is something in my view.

Admiral Fishbourne: I do not think that Mr. White has laid sufficient emphasis upon the position and the height of the centre of gravity. It has an immense influence in limiting the turning powers. Of course his theory is all right when two ships compared are equally bad or equally good; but it is an essential point that you shall get ships with good turning power. Take the case of the "Eurydice." The "Eurydice's" centre of gravity was 2 feet 4 inches above the water-line, while the "Thunderer's" centre is nearly 3 feet below. See what a range that involves. As a necessary consequence of being thus high, you get a great inclination, which is very damaging. For fighting purposes it also limits the turning power, and is dangerous. Thus a fine ship in the Mozambique put her helm down and turned over; her centre of gravity was very high, she not having taken in sufficient ballast. Mr. White seemed to say that it turned simply upon the height of the metacentre. It depends rather upon where the metacentre height is measured off, whether high up or low down. Again, the draught of water has a very considerable influence on the turning, because if the centre of lateral effort of the water is low down, and the centre of gravity is high up, there is a long leverage, and the tendency is to increase in the inclination, and limit the power for turning. It is of course very desirable in every ship to have a history of all this, for the ship that has the quickest power of turning is the ship that has the greatest advantage in all evolutions, and she is also the safest ship. A ship which is not entirely under the power of her helm is not a ship at all; she is a danger to herself and to her neighbours, and the cause of a great number of collisions is, vessels not being under the power of their helms. The contrast will be so great between one ship and another in turning, that the cause will, hunted up and corrected, lead to an improvement in naval architecture.

Commander Curtis: I should like to hear what Mr. White has to say about the

balance rudder, because I remember a navigating Officer saying, when conversing on the use of bow rudders, that his vessel had two balance rudders; she went from Malta to Corfu with the bow rudder across her, hard over, and they never found it out until they anchored at Corfu. That fully confirms what Mr. White says, that a bow rudder, especially a balance one, has very little influence on a ship when she is going ahead. I was once in command of a gunboat, in June, 1862, the "Growler," in whose turning powers I had great confidence. There was a review at Malta; the Prince of Wales was at Signal Station, with other grandees, and I was ordered to run close under the fortifications of Quarantine Harbour as far as I could. Admiral Codrington ran up the Grand Harbour in Her Majesty's ship "Hasty." We steamed full speed close under the fortifications abreast the powder magazine and opposite the packet pier, 84 yards width, where I saw the French packet about to start for Marseilles. I wanted to show off a little, and I ordered the quartermaster to put the helm down as hard as he could; we were under full steam, not having the tiller tackle on, it took four of us to put the tiller over. I ran forward, and to my horror, the vessel did not appear to be turning at all; and I had visions of court-martial and all sorts of things for running the French vessel down. When, however, I turned aft, I found the vessel was like the leg of a pair of compasses, so to speak, she was turning on her fore foot apparently, and I was quite elated. I wished the Frenchman "Good morning; good voyage," and so forth. I could have stepped over the bows of my vessels on to his accommodation ladder, when I righted the helm and went on. Anyone who knows the Quarantine Harbour at that point will know that there is not very much distance between the packet pier and the rocks under the fortifications, and this appeared to me to confirm what Mr. Scott Russell has said, that the vessel will pivot very nearly on the fore-foot.

Captain J. C. R. Colomb, R.M.A.: I wish to ask a question on the variation of draught, whether or not that variation is an important element in the question? Because I find in a small yacht that it really has a most extraordinary effect. I should also wish to know if there has been any experience to determine the value of a patent log as a means of measurement, that is, comparatively with ascertained measurement by observation.

Captain Long: I should like to make one remark about the importance of the drift-angle. Of course if you know the radius of the circle of turning, and the distance between the pivoting point and the centre of gravity, there is no difficulty in reducing the drift-angle.

The Chairman: I trust that this paper, which will be a very valuable addition to our Journal, may have some effect in inducing those in authority to give us the opportunity of having experiments tried on the turning powers of various classes of ships. If those that have been tried in the "Thunderer" are followed out, they will be of very great importance to the Service, and I have no doubt that the influence which Mr. White undoubtedly has in his own department will enable him to get these experiments carried out. The Service would be much gratified if they could be. It is impossible to over-rate the importance of this question of turning-power, bearing in mind that in a fleet the whole movements of the ships composing it depend upon the slowest turning ship, inclusive of the time she takes to put her helm over. I found this very markedly lately when the "Warrior" happened to be one of a squadron under my command; our movements were regulated by hers. She is 400 feet long, and had only manual labour to move her helm. With regard to the remarks which fell from Mr. Scott Russell, I would observe that one thing has always struck me as most important, that is, the difference of pressure on the bow and stern of a moving ship: not that caused by the raising of the wave, but the pressure against the bow caused by the motion of the vessel according to the speed at which she is going, accounts for her turning on a certain point far before the centre of gravity. I believe that is a most important fact to be recognised in discussing the movements of a ship when she is turning. Mr. White has said that he has put on one side all question of wind and sea; but this question of the difference of pressure on bow and stern and of the point being so far forward on which she turns, affects us very considerably when there is any wind. When you are going ahead you do not feel it, because a slight touch of your helm moves the after part of your ship and counteracts the effect of the wind; but the very slightest

wind on your beam will bring you up head to wind; and, when you are going astern, the very slightest wind on either side will bring you up stern to the wind, and your helm then is of little use. When Mr. White says it is very easy to give information about the steering power of a twin-screw, I think he says that the only points necessary to know are the revolutions of screw, the speed of ship, and the angle of helm required to keep the vessel straight; but the direction and force of the wind is another most important point.

One other point about "heeling" when turning. In trying ships on the measured mile, I soon observed the heeling of the ship as she turned at full speed. I at once discarded the idea of the pressure on the rudder being the cause of it, and felt assured it was what is called the centrifugal action, more properly the momentum of the upper works, and I observed that it was much more in masted ships than in unmasted ships. In the case of the French ships that were compared, they heeled over two degrees. The English ship was the "Thunderer," without masts, and if the French ship had masts that would in a manner account for the difference.

Admiral FISHBOURNE: She was masted and of great draught.

The CHAIRMAN: That to my mind would account for it. I do not think I should quite recognise the fact that it is only due to the metacentric height. To my mind it is due to the moment of inertia of the weights above water, or as the square of the height of the centre of gravity of the weights above water. I cannot help thinking it is more than simply as the metacentric height. I believe if you were to bring down all your spars from aloft and put them on deck it would not appreciably alter your metacentric height. I am only putting this as a practical idea of what I have observed when ships have been turned. I cannot speak too highly of the value of this paper. It is a subject in which we are all interested to a great degree, and we shall be very glad to hear Mr. White answer the questions which have been addressed to him.

Mr. WHITE: First of all, I must express my deep obligations for the kind way in which this paper has been received. I could not help feeling in preparing it that I was coming here before a number of gentlemen who had many opportunities of making experiments such as I can never hope to have. I know something about the management of small vessels, but the management of large steamers is a thing which I have simply looked at while other people did the work; I have therefore confined myself, so far as I could, to the statement of principles which are of general acceptance, and of facts which I believe to be well authenticated. I have spared no labour in searching for facts, and my great object has been, in putting these facts before you, to ask for other facts. However much diagrams of the character which Mr. Scott Russell has put on the board may help us to understand the effect of the motion of the surrounding water on a vessel (either while going ahead, or while turning), I think that any one who has attempted to make observations of the wave motion during steam trials will know that it is one of the most difficult subjects we have to face. We do not know exactly what is going on in the water surrounding the ship; and I am confident that a great many of those difficulties which arise in explaining the behaviour of different ships, arise from differences in the relative motions of the water and the ship.

I will first take up the questions which refer to heeling. Of course in this diagram (Fig. 2) the position of the "centre of lateral resistance" depends greatly upon the draught of water. If instead of being what it is—a ship-shape form—it was simply a board pushed sideways, we could determine pretty closely where the centre of lateral resistance would be. But it is quite evident that in a ship-shape form, if the draught is increased, retaining similar form, you will lower the line of action of the lateral resistance; and if the centre of gravity could be kept to the same vertical position there would be an increase in the arm of the couple producing heeling. I quite endorse what Admiral Fishbourne said, viz., that an increase in draught not merely affects the resistance to rotation, but also affects the heeling of the ship. Of course variations in the height of the centre of gravity in the ship will also affect the heeling. Supposing it were possible to bring down all the spars from aloft—although their weights are small, their vertical transfers would be great—and there would be quite a sensible fall in the centre of gravity. The effect on the heeling would be felt especially in small vessels, where the arm of the heeling couple is

small, and the fall of the centre of gravity may cause a decrease in that distance which may be proportionately considerable. When we come to the question of a steady heel, the inertia of the ship is a factor which goes out of consideration. It seems to me mainly a question of vertical position of the centre of gravity, and of the centre of lateral resistance. I was delighted to hear Admiral Sir Cooper Key put on record his experience of the heeling in rigged ships, because it is a matter which probably will cause further inquiry to be made. The height of the centre of gravity will not merely affect the leverage of the heeling forces, but will also affect the metacentric height, that is the position of the centre of gravity in relation to the metacentre, which will govern the statical righting moment of the ship. As to the diagram which Mr. Scott Russell drew upon the board, it will suffice to say that the peculiar curvature of keel which he adopted would involve some small difficulties in docking and other difficulties of a practical character which I need not specify. Then as to the wave drawn by Mr. Scott Russell, I myself have some acquaintance with observations of actual waves. I have, for example, been outside the "Iris" when she has been running at nearly 19 knots an hour, but I have never seen anything approaching Mr. Scott Russell's drawing. Although I do not pretend to say what is going on in the water, I do venture to say that Mr. Russell's drawing does not represent what is going on. It must not be forgotten also that, when the vessel is on a straight course, there are the waves on both sides. The distribution of the pressure is due to dynamical conditions in this case, and not to statical. It is incorrect to count it in as a dynamical pressure, and also a statical pressure. I will not, however, pursue this matter further. I do not say that I have taken into account all the forces in my statement as to heeling, because when I speak of lateral resistance I speak of a thing which I really know little about, and I think that nobody knows much about it. We know that there must be some force on the outer side of the ship, which balances the forces on the inner side. When we get a correct measure of the moment which has to be overcome before the ship heels, then, whether we take into account all the forces or not, we get a fairly correct representation of the heeling couple; that is all I have endeavoured to explain as regards the heeling.

As regards the pivoting point (P, Fig. 1), I fully endorse what has been said by various speakers. From the point of view of the Officer who has to direct the ship, P is the pivot point, and that is the all-important thing to him. He does not care very much where the centre of the circle may be. He wants to know where the head of his ship is going. But in a mathematical sense I hope I have made it clear, that the centre of the circle is the centre of motion. As a basis for framing complete equations of motion I do not think that Captain Colomb's diagram would be accurate. The principle of the "conservation of motions of translation and "rotation" enables the equation for rotation to be framed as if the centre of gravity were fixed, provided only that the whole of the forces are taken into account. I do not think we are safe to assume that we know the line of action of the lateral resistance. I hope before long, however, that we may have the opportunity of trying, in one of the torpedo boats, an experiment to determine what that vessel will do with a drop bow-rudder, and with the helm kept to midships, as Captain Colomb suggests; so that I will not venture an opinion. There were other matters in Captain Colomb's remarks to which I should have been glad to have referred, but I am afraid I have not the time to do it.

The differences in the revolutions of the screws in twin-ships when turning is a matter which is not so far developed in the "Thunderer" trials as in many other trials. But while I quite agree in principle with what Captain Colomb has said, I must say that differences of revolutions do not necessarily imply corresponding differences in thrust, because the screws are working in water, which is much affected by the motion of the ship. Unless we had dynamometrical experiments on the ends of the screw-shafts, I am sure we could not accurately estimate these differences of thrust. Repeated allusions have been made to the need for further experiments. I should be delighted to see such experiments, and may again refer to statements made in the paper. Each new ship of the Navy, and many old ships, have on board "Captain's ship books," which give such information as is considered valuable to the Officer in command. Amongst other things are recorded the "Constructor's

"steering trials," and the results of measured mile trials, with all such information about the machinery as may be given in tabular form. There is also a printed form, directing that further steering experiments of various kinds shall be made. The question of expense is one with which I have no concern; but I can assure you that in these printed forms there are detailed headings, with most distinct instructions that, for every new ship during the first year or two of her commission, steering trials shall be made. There are spaces and columns in which to record the whole of the particulars of the trials; so that when a new Captain comes to the ship, he ought to have in his hands the whole of those particulars, which will save him the labour of making corresponding experiments. Sir Cooper Key has alluded to the "Warrior." I know that she was not the only ship in his fleet which gave him some anxiety about her steering; but I am happy to be able to say, nearly a year ago, a steam steering engine was ordered for the "Warrior," and it is only waiting the opportunity to be put on board.

Captain Long spoke of the steering of the "Thunderer," and the turning *outwards* of the screws. That turning outwards was adopted after careful trial. It was found that there was a sensible gain in speed, and it was adopted for that reason; but I am bound to say, so far as the steerage goes, it seems to me that is the proper way to put the screws; because the streams delivered from the lower blades then have the greater chance of reaching the rudder. While I have the greatest respect for the experience of the Staff Commander of the "Thunderer," I believe I am right in saying that, in all the extensive steering trials, the vessel was perfectly under command at all the speeds at which she was tried. And I know, as to both the "Thunderer" and "Devastation," I have always heard them spoken of as most manageable and well-behaved ships. As to the effect upon the steerage, produced by filling compartments forward, it is obvious that there must be considerable difficulty in saying beforehand what would happen. This is certain, that a vessel in such a condition must be much less under control; and that it would arise not merely from the change of trim, but from the fact that the masses of water which are locked up in the vessel forward would very much affect her inertia. Besides that, the rudder would be somewhat put out of action by being less immersed, and there would be many other disturbing conditions. I can tell you, however, what has happened in many vessels which have got very much out of trim. Some time ago several vessels were built with the idea of having enormous foreholds for cargo. The machinery was pushed very far aft, and all the coal was carried aft, so that by the time the ships reached their port they were about 6 feet by the head, instead of being on an even keel; I am told that these ships did not steer well, and that they got up to their port with very great difficulty indeed, and their type has not been multiplied. As to the trial of the "Hankow," and her slow turning, Captain Long is aware that in that ship there was only manual power; I believe they took one minute and three-quarters to put the helm over. There is another thing worth noting about the steamer. Having only manual power at the helm, the temptation is to make the rudder-area small, and it is ridiculous, as compared with our practice in the Navy, to see the rudders that are put upon many merchant steamships, including some vessels which have steering engines where there is no reason for using small rudders. I cannot help thinking that mercantile shipbuilders might with great advantage look to it, whether they could not increase the rudder areas in their ships, now that we have mechanical steering. Judging by the "Hecla," we find that the rudder area in merchant ships might with advantage be increased if there is steam steering. With regard to Captain J. Colomb's question as to the effect of draught upon the turning qualities of a ship, I would remark that if you increase the draught you must increase the resistance to rotation and conversely. To facilitate the manœuvring of racing yachts, great differences of draught are often adopted at the bow and stern. The well-known "Jullanar" is a remarkable case; her draft aft is about 16 feet and forward only a few inches.

Captain J. C. Colomb: I meant to ask whether the variation of draught, caused by the probable exigencies in the service, is an element that would materially affect the turning powers of these ships; because in small vessels I know for a fact that it does.

Mr. White: It is so in merchant vessels, where there are great variations in draught. When merchant steamers are being transported light, they are often

under little control. There are several causes for that. Of course the decrease in draught would lead to a decrease in resistance to rotation, but that carries with it usually the partial emersion of the screw, and also of the rudder-area, and there is a greater readiness to heel. All those things influence manœuvring. A ship is, no doubt, under most perfect control when she is in her load condition. Lastly, I am not aware that we have made any experiments in England with the patent log to determine its accuracy for use on steering trials. I think it is likely that such experiments may be made; but the French have made experiments, and they report against the patent log. Lieutenant Coumes has published some results.

The CHAIRMAN: I am sure I may have your permission to return our most cordial thanks to Mr. White.

APPENDIX A.

TURNING EXPERIMENTS WITH THE STEAM-SHIP "HANKOW," COPIED FROM THE REPORT OF THE BRITISH ASSOCIATION COMMITTEE FOR INQUIRY INTO THE STEERING OF STEAM-SHIPS, 1877.

The "Hankow" is a single screw steam-ship, of 3594^{12} gross tonnage; net, 2331^{75} tons. Length, 389 feet; breadth, 42 feet 1 inch; depth, 28 feet 8 inches.

Her propeller is four-bladed, right-handed, with a diameter of 20 feet, and pitch from 24 to 26 feet. The mean angle of its surface with a vertical athwartship plane would be 21°, hence the streams would be delivered on an average at an angle of 21° from the vertical fore and aft plane.

Experiments were conducted on March 8th, 1877, in lat. 8° 50′ S., long. 153° 58′ E., between 9.20 and 11.30 a.m. as follows:—

Sea smooth, or between 1 and 2 of Beaufort scale; ship drawing probably 24 feet 8 inches forward, and 23 feet 8 inches aft.

First Experiment.

Ship going ahead full speed (say 10 knots), engines were suddenly reversed, helm put hard aport; immediately the engines started, time noted, and bearing of ship's head by standard Admiralty compass noted, and the bearing of the ship's head also noted at every 15 seconds, until ship came to a dead stop.

Time.			Interval.		Ship's head by compass.	Head turned to	
						Port.	Starboard.
h.	min.	secs.	m.	secs.			
9	20	7	..		N. 62 W.		
9	20	22	0	15	„ 62½ „	0½	
9	20	37	0	15	„ 66 „	3½	
9	20	52	0	15	„ 69 „	3	
9	21	7	0	15	„ 73½ „	4½	
9	21	22	0	15	„ 77 „	3½	
9	21	37	0	15	„ 80 „	3½	
9	21	52	0	15	„ 84½ „	4	
9	22	7	0	15	„ 88 „	3½	
9	22	22	0	15	„ 88 „	Stationary.	
9	22	37	0	15	„ 87 „	..	1
9	22	52	0	15	„ 85½ „	..	1½
9	23	7	0	15	„ 84 „	..	1½
9	23	22	0	15	„ 82½ „	..	1½
9	23	37	0	15	„ 79½ „	..	3
0	3	30	3	30	—	26	8½

Ship came to a dead stop in 3 m. 30 secs., and turned to port 26° in 2 m., and then to starboard 8½° for 1½ m.

Second Experiment.

Ship going ahead full speed, say 10 knots. Engines suddenly reversed to full speed astern; helm put hard astarboard, bearing of ship's head taken, and time as before.

Time.			Interval.		Ship's head by compass.	Head turned to	
						Port.	Starboard.
h.	min.	secs.	m.	secs.			
9	45	30	..		N. 3 W.		
9	45	45	0	15	„ 91 „	2	
9	46	0	0	15	„ 41 „	Stationary.	
9	46	15	0	15	„ 49½ „	..	1½
9	46	30	0	15	„ 37½ „	..	2
9	46	45	0	15	„ 32½ „	..	5
9	47	0	0	15	„ 38 „	..	4½
9	47	15	0	15	„ 24½ „	..	3½
9	47	30	0	15	„ 21½ „	..	3
9	47	45	0	15	„ 28 „	..	3½
9	48	0	0	15	„ 13 „	..	5
9	48	15	0	15	„ 19 „	..	4
9	48	30	0	15	„ 5 „	..	4
9	48	45	0	15	„ 2½ „	..	2½
9	48	53	0	8	„ 2 „	..	0½
0	3	23	3	23	—	2	39

Ship came to a dead stop in 3 m. 23 secs. Her head payed off to port 2° during the first 15 secs., and afterwards turned to starboard 39° before coming to rest.

Third Experiment.

Ship going full speed ahead, say 10 knots, the engines suddenly reversed to full speed astern, the helm put amidships, the bearing of ship's head noted by azimuth compass as before. Sea, wind, and weather as before.

Time.			Interval.		Ship's head by compass.	Head turned to	
						Port.	Starboard.
h.	min.	secs.	m.	secs.			
10	34	16	..		N. 29½ E.		
			0	15	„ 29 „	0½	
			0	15	„ 29½ „	..	0½
			0	15	„ 30½ „	..	1
			0	15	„ 32 „	..	1½
			0	15	„ 36 „	..	4
			0	15	„ 39 „	..	3
			0	15	„ 44 „	..	5
			0	15	„ 46½ „	..	2½
			0	15	„ 48 „	..	1½
			0	15	„ 50½ „	..	2½
			0	15	„ 51½ „	..	1
			0	15	„ 52 „	..	0½
			0	15	„ 53½ „	..	1½
			0	15	„ 54 „	..	0½
			0	15	„ 54½ „	..	0½
			0	15	„ 55 „	..	0½
10	38	31	0	15	„ 56 „	..	1
0	4	15	4	15	—	0½	27

Ship came to absolute rest in 4 m. 15 secs.; her head turned to port 0½°, and then 27° to starboard, before coming to rest.

Fourth Experiment.

In this case ship was going full speed astern, say about 9 knots, when the engines were suddenly reversed to full speed ahead; helm put hard to port; time and azimuth of ship's head noted as before. Sea, wind, and weather as before.

Time.			Interval.		Ship's head by compass.	Head turned to	
						Port.	Starboard.
h.	min.	secs.	m.	secs.			
11	3	11	..		S. 65½ E.		
			0	15	„ 66 „	0½	
			0	15	„ 67 „	1	
			0	15	„ 67½ „	0½	
			0	15	„ 67½ „	Stationary.	
			0	15	„ 66½ „	..	1
			0	15	„ 65½ „	..	1
			0	15	„ 63½ „	..	2
			0	15	„ 60½ „	..	3
			0	15	„ 57½ „	..	3
			0	15	„ 53½ „	..	4
11	5	56	0	15	„ 48 „	..	5½
0	2	45	2	45	—	2	19½

Ship came to a dead stop in 2 m. 45 secs., and her head turned 2° to port in the first 45 secs., and 19½° to starboard in the next 2 minutes.

Fifth Experiment.

Making the circle from rest; hard to port; full speed ahead. Wind and sea as before.

Ship started at full speed from absolute rest, with the helm hard aport, and at the instant of starting an empty flour barrel was dropped from the stern, to mark the point started from.

Time.			Interval.		Ship's head by compass.	Arc turned.
h.	min.	secs.	m.	secs.		
9	27	54	—		N. 56½ W.	
	28	24	1	30	„ 54 „	2½
	28	54	0	30	„ 49 „	5
			0	30	„ 38 „	11
			0	30	„ 28 „	10
			0	30	„ 18 „	10
			0	30	„ 5 „	13
			0	30	N. 6 E.	11
			0	30	„ 19 „	13
			0	30	„ 30 „	11
			0	30	„ 43½ „	13½
			0	30	„ 58 „	14½
			0	30	„ 74 „	16
			0	30	„ 89 „	15
			0	30	S. 75 E.	16
			0	30	„ 61 „	14
			0	30	„ 46½ „	14½
			0	30	„ 33 „	13½
			0	30	„ 20 „	13
			0	30	„ 7½ „	12½
			0	30	S. 4½ W.	12
			0	30	„ 16½ „	12
			0	30	„ 30 „	13½
			0	30	„ 45½ „	15½
			0	30	„ 61 „	15½
			0	30	„ 78½ „	17½
9	40	54	0	30	N. 84 W.	17½
9	41	24	0	30	„ 67 „	17
9	41	40	0	16	„ 57 „	10
0	13	46	13	46	—	Mean angular velocity, 27′ per second.

Ship came outside barrel about 150 feet, when it was abreast taffrail, *i.e.*, it was on our starboard side at conclusion.

(Signed) W. Symmington,

Commander Steam-ship "Hankow."

APPENDIX B.

Description of Plan for Ascertaining Ships' Curves when Turning, proposed by Captain Long.

Shortly it consists of using Mr. Martin's plan, with one additional box or buoy, and two additional angles, the object being to connect the various points on the curve with the position of centre of gravity, when helm begins to move, and original course, as detailed by Mr. White.

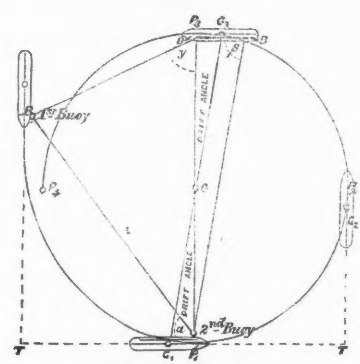
I need only remark that if a rolling batten were placed vertically at each extremity of base with a white mark at height of observer's eye, there seems no reason why the angles should not be taken with a sextant.

Observations required—

1. At instant of moving helm drop a buoy from inner bow abreast cross battens; note time.
2. Note time helm is hard over.
3. When ship has turned through 90°, drop a second buoy from same place, and observe the angle α subtended by the first buoy, and after end of base line; note time.
4. When the second buoy comes abeam by cross battens, at fore end of base line, take angle β from after end, as in Mr. Martin's plan, and also angle γ from fore end of base line, being angle between the two buoys; note time.
5. Note time ship has completed circle.

If an accurate account of speed is required, which is most desirable, one of the methods, either Dutchman's log observations, or Sir Cooper Key's plan, as mentioned by Mr. White, must be used.

H.M.S. "Thunderer's" 3rd Experiment Plotted to show Proposed Method.



Scale $\frac{1}{7}$ inch = 100 feet.

PP_1, &c., positions of pivoting point of ship.
GG_1, &c., „ centre of gravity.
C centre of circle.

Calculation.

In triangle P_1BD if l be the length of base line on board—

$$l \tan \beta = \text{final diameter, or } P_1P_3.$$

$$\text{In triangle } PP_1D \text{ angle at } P = 180 - \left\{\gamma + \overline{90 - \alpha}\right\}$$

$$\text{Hence } PP_1 \text{ or chord of 1st quadrant} = \frac{P_1P_3 \sin \gamma}{\sin P}$$

$$= \frac{l. \tan \beta \sin \gamma}{\sin P.}$$

Also TT, or tactical diameter, $= \dfrac{P_1P_3}{2} + PP_1 \cos\ \alpha$; and drift-angle, or P_1CG_1 may be found from $\tan C = \dfrac{P_1G_1}{R}$, R, being radius of circle.

As an example, I have taken the angle supposed to be observed off the plan, in a convenient form of record.

Time.			Interval from origin.		Observations.
h.	min.	secs.	m.	secs.	
12	32	42	..		Helm began to move, dropped buoy No. 1.
12	33	1	0	19	Helm hard over.
12	34	11	1	29	Ship turned 90°, dropped buoy No. 2, obsd. $< \alpha = 54°$.
12	36	40	3	58	Ship turned 270°, obsd. $< \beta = 80° 30' < \gamma = 68°$.
12	38	2	5	20	Circle complete.

Any number of additional observations might be made as to times of passing through various azimuths, speed, &c.

The above may be plotted to scale or worked out thus:—

$$
\begin{array}{lr l}
\text{Log. } l = & 2{\cdot}301030 & \\
\text{Log. } \tan \beta = & {\cdot}776394 & \\
\hline
\text{Log. } P_1P_3 = & 3{\cdot}077424 & \text{final diameter} = 1{,}195 + 50 = 1{,}245 \text{ feet.} \\
\text{Log. } \sin \gamma = & 9{\cdot}967166 & \\
\hline
 & 13{\cdot}044590 & \\
\text{Log. } \sin P = & 9{\cdot}986904 & \\
\hline
\text{Log. } PP_1 = & 3{\cdot}057686 & \text{chord of 1st quadrant} = 1{,}142 \text{ feet.} \\
\text{Log. } \cos \alpha = & 9{\cdot}769219 & \\
\hline
\text{Log. } TP_1 = & 2{\cdot}826905 & TP_1 = 671 \text{ feet.}
\end{array}
$$

$$\frac{P_1P_3}{2} = 622 \text{ feet.}$$

TT 1,293 feet.

Add half-breadth of ship .... 31 feet.

1,324 feet, tactical diameter of centre of ship.

Also tan C, or drift-angle $= \frac{P_1 b_1}{R} = \frac{98}{620}$

$$\begin{array}{lcl} \text{Log. } 98 & = & 1{\cdot}991226 \\ \text{Log. } 620 & = & \underline{2{\cdot}792392} \\ \text{Log. tan C} & = & 9{\cdot}198834 \quad C = 8^\circ\ 59'. \end{array}$$

The drift-angle for any point of a ship is the angle; an object must be before the beam (if abaft pivoting point) in order to turn round it without altering distance.

Space forbids entering at present into the numerous practical questions which present themselves. I would only remark that all methods share the defect of difference of drift between ship and buoy, and if anything beyond the final diameter is required, we at once get upon the question of obtaining correct azimuths which I touched on in my remarks.

As the length PG can only be determined by experiment, and is variable at different speeds and helm-angles, it will be most satisfactory if G is made the centre of the base line, when G_1G_3 can be easily deduced from the final diameters. The accurate length of PG is only required for the determination of drift-angle, and angle β is in fact very nearly equal to the drift-angle.

LECTURE.

Friday, March 21, 1879.

ADMIRAL SIR R. SPENCER ROBINSON, K.C.B., in the Chair.

ON THE LATEST IMPROVEMENTS IN MARINE ENGINES AND BOILERS.

By JOHN R. RAVENHILL, Esq., M.I.C.E.

IN a paper read by me before the Institution of Naval Architects at an autumnal session, held at Glasgow in 1877, I drew attention, amongst other subjects, to the great strides that had taken place in ocean steam navigation since the "Great Western" steamship commenced her passages to and fro to New York in 1839. Having compared her performances with some of the fastest transatlantic steamers then running, and having alluded to the rapid increase in the use of the compound engine, I conclusively proved from results obtained the great advantages in the saving of fuel that were being derived from its adoption, pointing out that the consumption of coal was reduced, say, from 8 lbs. per indicated horse-power per hour to 2 lbs. I also showed that the average length of the voyage had been practically reduced one-half, and in a lengthy appendix I added a list of the then compounded commercial fleet belonging to seventeen of our principal steamship companies.

The "City of New York," belonging to the Inman Line, at that time fitting for sea with compound engines, by the Sunderland Engine Works Company, has been running on her station for some fifteen months, and her average consumption of coals per hour is stated to be 1·9 lbs. per indicated horse-power under favourable circumstances, with sails set, the speed of the vessel being 14 knots per hour. Her engines are of the compound vertical type, with four cylinders; the high pressure ones, each 40 inches in diameter, standing above the low pressure ones, which are 71 inches in diameter, having thus a proportion of 3·15 to 1; they have a stroke of 5 feet, and are fitted with expansion valves arranged to cut off the steam at from one-quarter to three-quarters the length of the stroke in the high pressure cylinders. The surface condensers contain an aggregate tube surface of 5,000 square feet. The steam is supplied by 4 boilers, double-ended, having 6 furnaces, in all 24, each with its own separate fire-box; they carry a working pressure of 75 lbs. on the square inch, and contain a total

heating surface of 10,000 square feet. After twelve months' working her consumption of coal is given me as 62·75 tons per day, and it is claimed for the engines that every part of them is very easily overhauled in the event of need.

The service, however, which had just then been commenced by the Orient Line between London and Sydney, with vessels originally belonging to the Pacific Steam Navigation Company, is perhaps the one above all others that has been the most *keenly* watched by all interested in steam navigation; and having regard to the distances run, and the speed maintained, it deserves special notice. The outward voyages are made round the Cape of Good Hope, the homeward through the Red Sea and the Suez Canal; and the following table may prove interesting as an example of one of their voyages.

TABLE I.

Ports from.	Ports to.	Distance.	Consumption of Coal.	Actual Steaming Time.			Average Speed.
		Miles.	Tons.	D.	H.	M.	Knots per hour.
Outward—							
London ..	Gravesend ..	22	7	..	2	34	..
Gravesend ..	Plymouth ..	300	53	1	2	4	..
Plymouth ..	St. Vincent ..	2,248	355	7	15	46	12·2
St. Vincent	Cape of Good Hope ..	3,948	659	13	22	50	11·8
Cape Town ..	Adelaide ..	5,714	859	18	0	40	13·2
Adelaide ..	Melbourne ..	520	85	1	17	30	12·5
Melbourne ..	Sydney	586	96	1	21	41	12·8
		13,338	2,114	44	11	5	12·5
Homeward—							
Sydney ..	Melbourne ..	580	102	1	23	21	12·2
Melbourne ..	Adelaide ..	500	100	2	..	..	10·4
Adelaide ..	Suez	7,455	1,500	26	6	26	11·8
Suez.. ..	Port Saïd ..	86	22	..	15	..	..
Port Saïd ..	Plymouth ..	2,990	512	10	16	45	11·7
Plymouth ..	Gravesend ..	300	54½	1	7	30	..
Gravesend ..	London	22	4	..	2	27	..
		11,933	2,294½	42	23	29	11·5

Totals for round voyage between Plymouth and Sydney after deductions made for Canal, and the distance between London and Plymouth :—

Distance in knots	24,561
Average speed per hour in knots	12
Total consumption of coal in tons	4,268
Consumption of coal per mile in cwts. ..	3·48

The speeds between Plymouth and Sydney give an average, say, of $12\frac{1}{2}$ knots per hour, extending over 43 days 6 hours 27 minutes; and the return voyage through the Suez Canal, after deducting the time occupied in passing through it and its mileage length, averages $11\frac{1}{2}$ for 42 days 8 hours 29 minutes, a performance which, having regard to the distances steamed over and the speed maintained, is, I believe, at the present moment without a parallel. The times occupied between the various ports show at a glance at what periods of their voyage the sails can be used with advantage.

The vessels at present employed are the

"Lusitania"	"Chimborazo"	"Cuzco"
"John Elder"	"Garonne"	"Aconcagua"

of about 4,000 tons register, and 550 to 600 nominal horse-power.

This company is building a large vessel on the Clyde at the present time; and among other well-known ship-owners, who are also adding to their fleet, may be mentioned the names of the Peninsular and Oriental Company, the British India Steam Navigation Company, Messrs. Money Wigram and Sons, and the Liverpool and Great Western Steamship Company (the Guion Line). This latter vessel is to be fitted with engines of the largest class of the three-cylinder vertical type; the high pressure cylinder will be 62 inches in diameter, and the low pressure cylinders each 90 inches in diameter, with a stroke of 5 feet 6 inches. The boilers are to carry a working pressure of 90 lbs. on the square inch, and the engines are to work up to an indicated power of 6,000 horses. The diameter of the crank shaft necks will be 23 inches, and the shaft itself will be made up in pieces. They are being constructed by Messrs. John Elder and Co.

It is not, I believe, generally known at the present day that a compound paddle-wheel engine was at work on the Thames between London and Richmond as far back as the year 1841 in a passenger steamer called the "Era." It was a Woolf's engine, with the high-pressure cylinder $17\frac{3}{8}$ inches in diameter, and the low pressure 29 inches, with a length of stroke of 20 inches; the boiler carried a working pressure of 40 lbs. on the square inch, and steam was cut off in the former at 6·6 inches in its length.

The engine was fitted with a surface condenser, steam regenerator, &c., on the system patented by Mr. Zander, a native of Sweden, the condensation of the steam being effected by its passing through a series of zigzag vertical plates, against the surfaces of which it was condensed. The boiler was on the water-tube system, on Mr. Spiller's plan—I believe the engines were made by him—and a saving of two-thirds of the ordinary consumption of fuel was claimed for the performance. Coke, and not coal, was used on board.

You will ask, and not unnaturally, how it was that, with such obvious advantages arising from the use of the compound engine, the system was allowed to slumber in London for so lengthened a period. The answer, I believe, is only to be found in the utter dislike that existed amongst steamship owners, engineers, and the travelling public in London to the general introduction of higher pressures than from 20 to 30 lbs. on marine boilers; and the fatal boiler explosion

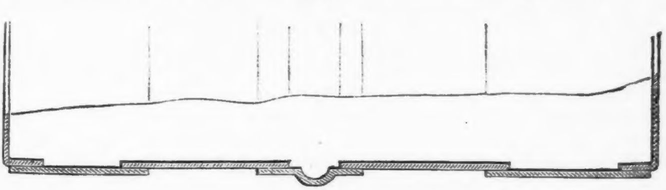
on board the "Cricket" in the year 1847 tended greatly to this result. In time, however—but many years had glided away—the advantages of the compound engine, working from 40 lbs. on the square inch and upwards, became so apparent, that it has come to be the engine of the day. Pressures have been increased in transatlantic vessels to 90 lbs. on the square inch, and machinery to indicate 5,500 horses is being constructed for the Navy to work at a pressure of 120 lbs. per square inch on the boilers.

Generally during the last two years, steamship owners and others have been endeavouring rather to perfect what has been already done and profit by their experience than to introduce new schemes.

Boilers are now being made of iron 15 feet diameter and upwards, with a thickness of casing plates $1\frac{5}{32}$ inch, and with pressures creeping up to 90 lbs. on the square inch; boilermaking can no longer be left in the hands of the ordinary boilermaker, it has become imperative that all the various laps, joints, butt plates, &c., should be all fitted together by first-class workmen. The cylindrical form of boiler is universally adopted, and the pressure proposed for new boilers is fast approaching the average of 80 lbs. on the square inch; they are on the return tube system, and have circular fire-places and are fired at one or both ends as may best suit the requirements of the vessel; if on the latter principle they are fitted in some instances with a fire-box or combustion chamber common to all the fire-places, having Galloway's tubes introduced vertically in them; in others again the fire-boxes open; whilst some engineers prefer fire-boxes with a water space between them running across the diameter of the boiler, and others a separate fire-box to each separate fire-place.

Fox's corrugated furnace is being introduced. At a series of extensive experiments that were conducted at the Leeds forge before officials connected with the Admiralty, Board of Trade, and Lloyd's, it was proved that such a furnace of the same diameter and thickness of plates is about cent. per cent. stronger than the ordinary circular form, and it has (due to its corrugations) considerably more heating surface. An interesting trial, in two mail steamers of about the same tonnage dimensions, has just been made with these furnaces, the engines being duplicates of each other. In the one, the boilers were fitted with 18 plain furnaces, and had a grate surface of 294 square feet; in the other the boilers had 12 corrugated furnaces, and a grate surface of 260 square feet, the steam generative power of both was practically the same, and the speed of the two vessels equal.

Hepburn's expansion ring is made of the same thickness as the shell and connects the two centre plates in boiler casings thus:



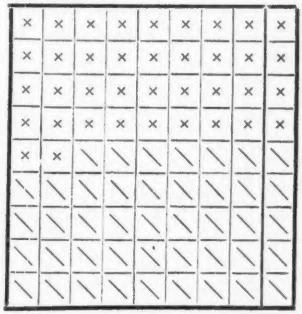
with a view to obviate the ill effects of the unequal expansion that takes place in the shell, due to the difference of temperature between the top and bottom of boilers, and which during the period of raising steam is so great that pipes connecting the lower water spaces with the upper portion of the water surface are frequently fitted and a circulating current set in motion by means of a donkey pump, Weir's hydrokineter has also been introduced for a similar purpose, namely, to produce as equal a temperature as possible in all parts of the boiler. To continue this circulation after steam has been got up and during the voyage, Messrs. Menzies and Blagburn have fitted many vessels with their circulating tubes with the avowed object (1) to cause the water to circulate from the top where it is the hottest to the bottom, and so keep the thermal condition of the boiler casing equal, and (2) to carry also the protecting properties of the zinc plates that are placed to check the chemical action, from the upper portions of the boiler, to the parts below the fire-grates that at present suffer most from this destructive cause through want of proper circulation. The more effective the circulation the greater the evaporative power of the boiler, and with it is produced a less tendency for it to prime. Weir's feed-heaters are also finding favour with marine engineers, and the efficiency of boilers has been increased by their adoption; but it is only right for me to state that the Admiralty experiments tend to show that, if the most valuable properties of zinc plates are to be obtained, they should be spaced all over the inside of a boiler, at distances of not more than 6 feet apart. Other improvements have also been tried, such as building combustion chambers of bricks, making brick furnaces, &c., with a view to reduce both the weight of the boiler and the amount of water contained in it, and at the same time avoid the flat surfaces that require to be stayed in the fire-boxes, but in none of these cases have results equalled anticipation, and in most cases they have been condemned and removed.

Different forms of boilers have been introduced lately mainly with a view to carry higher pressures. Those of the water-tube principle with horizontal or slightly inclined tubes have not proved successful at sea, either from defective circulation or the tubes becoming choked up with deposit.

"Rowan's boilers" with vertical tubes have been at work for ten years, and a Passenger Certificate has been lately granted to a passenger steamer on the Tyne for three months, with machinery fitted on Mr. Loftus Perkins's system, where a pressure of 450 lbs. on the square inch is introduced, and it will be extremely interesting to hear the Report of the Surveyors of the Board of Trade when, at the end of the three months, a renewal of the certificate will doubtless be applied for. Gas coke is the description of fuel used.

Recent experience has taught us the great advantages that would accrue if access could be obtained to all the internal parts in boilers, and there is considerable room for improvement in this direction in the designs of many of those at work; but if a perfect form of boiler were produced to-morrow, several years would have to elapse before all those now at work would be worn out and replaced. Meantime,

the test of sounding by the hammer and drilling to ascertain the existing thickness of the plates must continue; but even with all the care bestowed by the employés of some owners and the Board of Trade officers, immunity from fatal accident has not been secured. I should like to see every plate that it is considered necessary to subject to the hammer test first carefully marked out in small squares, and a trained boilermaker, a lithesome spare man, capable almost of getting anywhere, engaged for the work. Let him make his mark thus \ (left to right) in each square as he proceeds in his examination; and let his superior officer, be he an engineer of the owners or an officer of the Board of Trade, follow him as far as may be in his power, make his mark the reverse way, and thus form a cross, and no portion of a plate should thus escape notice. It is only a revival to a certain extent of a good old custom allowed to fall into disuse, for I remember the time when, in most of the leading boiler shops, no plate that was to be exposed to the action of flame was permitted to be worked into a boiler without such previous test, and many a blister was thereby detected and the plates condemned.



The more serious character of the accidents that arise from the use of higher pressures, calls on all steamship owners for the exercise of the greatest care and caution in the periodical examination of their boilers. There are many of them that would find very great advantage from every repair and the result of every survey being duly noted in a book, and an entry made of any alteration effected in the working pressure of the boilers; such entries would enable them to trace without difficulty the history of all repairs executed since the particular boiler was first set to work, a history which, if properly recorded, would prove very valuable. I am induced to lay stress on this, for it is not long since I had a case before me officially where the owners preserved no records at all, and their superintendent engineer, a man who had been some months in their service, and in whom, up to that time, they had placed entire confidence, admitted, in cross-examination, that he did not know the pressures at which the safety-valves on the boilers of their different vessels were loaded. I need scarcely add that the fleet were not under Board of Trade inspection.

The Steam Department of the Admiralty have adopted a very excellent form of report for their periodical surveys, one well worthy the attention of many shipowners. It should be remembered that whilst reducing pressures on boilers in the Royal Navy means reducing the speed of the ship, and though the loss of speed is of less consequence probably there than under similar circumstances to them, boilers cannot receive too much attention and care at their hands with the view to ensure greater freedom from heavy repairs. Each day occu-

ped on such repairs involves a loss of the services of their vessel—in fact, a monied loss.

At the last annual session of the Institution of Naval Architects, two very interesting and instructive papers were read on "Steel for "Shipbuilding" and "The Use of Steel for Marine Boilers, and some "Recent Improvements in their Construction," the former by Mr. Martell, the Chief Surveyor, and the latter by Mr. Parker, the Chief Engineer of Lloyd's Register of British and Foreign Shipping. I commend them as worthy the perusal of all naval Officers; a very large amount of practical and useful information is contained in them.

In reply to a question put to him, Dr. Siemens thus described the nature of the material:—"Chemically speaking, the only difference "is, that what we call mild steel is pure iron; it is more essentially "iron than what is commonly sold as such; but, as regards the "physical properties of the material, it differs in many points from "iron, and ought not to be confounded with it; because, if we were "to call it iron and confound it with iron, we should think it right to "treat it in the same manner, whereas it requires in many respects "different treatment." Mr. Parker spoke of an average tensile strain of 28 tons on the square inch being the result obtained from over 80 tests.

In March of last year the Committee of the above Society passed sundry resolutions in regard to the use of steel in the construction of marine boilers:—

"In all cases where it is proposed to construct steel boilers for "vessels classed or intended for classification in this Society's Register "Book, the Committee will be prepared to sanction a reduction in the "scantlings of such boilers from those prescribed in the Society's rules "for boilers made of iron in the shell plates and stays to the extent "of 25 per cent., provided the following conditions be fulfilled:—

"1. The material to have an ultimate tensile strength of not less "than 26, and not more than 30 tons per square inch of "section.

"2. A strip cut from every plate used in the construction of "the furnaces and combustion chambers, and strips cut from "other plates taken indiscriminately, heated uniformly to a "low cherry-red and quenched in water of 82 degrees Fahrenheit, must stand bending to a curve of which the inner "radius is not greater than one and a-half times the thickness of the plates tested.

"3. All the holes to be drilled, or if they be punched, the plates "to be afterwards annealed.

"4. All plates that are dished, or flanged, or in any way worked "in the fire, except those that are in compression, to be annealed after the operations are completed.

"5. The boilers, upon completion, to be tested in the presence "of one of the Society's engineer-surveyors to not less than "twice the intended working pressure."

These resolutions were considered necessary, as it had been proved

that, in working these plates, the material, unlike iron, has its essential qualities very much injured by the ordinary operations to which it is subjected. The material is injured to the extent of 33 per cent. of its ultimate strength by the mere operation of punching, but by riming the holes out to $\frac{1}{16}$ of an inch larger, or by annealing the plate after it has been punched, the whole of the strength is returned. Another operation which injures steel to a greater comparative degree than iron is "flanging," and it is necessary in order to overcome the effects of this process to have the plates that are flanged subsequently annealed. If this precaution be not taken, it will probably be found that, after the work is completed, the plates will crack, and this circumstance has given rise to many surmises as to the cause of the apparently mysterious fractures that have been found in some steel plates. In conducting the operation of "flanging" with ordinary boilermakers' plant it becomes necessary to heat the plates locally, the effect of which is to induce in the vicinity of the heated parts a state of initial stress which in steel is much more severe than in iron. The annealing is sufficient, however, to set at rest all the disturbed particles, to relieve these strains, and thus restore the material to its normal condition. To reduce such mishaps, a firm of steel makers is now preparing plant to stamp out at two heats the front plates of a modern boiler ready flanged to receive the furnaces, and roll plates 40 feet long for casing plates, so that only one joint will be required circumferentially in many boilers.

During the last year, five cases of cracked plates have, I believe, occurred. It should be stated that these fractures were not confined to steel manufactured by any particular firm or by any particular process; they stood all the tests necessary, and without any apparent cause cracked in a most mysterious manner. Each of these cases has been investigated, and it has been proved beyond a doubt that the defect arose from improper treatment, especially in neglecting to anneal after "flanging." (*See* Appendix A.)

In the construction of steel boilers greater care and attention *must* be exercised with the workmanship than is required in the case of iron boilers, and the difference between the two materials and the consequent different manipulation required in each case must be realized, not only by the manager, but by the workmen who will have to use the material, for if the rivet holes in steel plates are "drifted" heavily and knocked about as iron plates usually are in boilermaking the material will be injured. We may expect to see steel boilers extensively used in preference to those made of iron where lightness or increase of pressure is an object, whilst if they are made with the care which this material requires, and it prove eventually as durable as iron, it will become a question whether a considerable reduction in the factor of safety may not still be found compatible with perfect safety and efficiency.

With regard to the relative amount of corrosion in steel as compared with iron very little can as yet be said, as so very much depends on the management. It is a question that can never be properly solved until the steel boilers at present in use have run for some

time longer. The feeling is rather at the present day that steel may not prove as durable as iron, but a recent report from Captain Dent, R.N., informs me that the steel boiler on board the London and North Western Railway Company's steam vessel the "Duke of "Sutherland," running from Holyhead under his superintendence, appears to the eye to be in the same condition as the iron one with which this vessel is also fitted, the two boilers being exactly similar in all their dimensions, the thickness of plates in the case of the steel one being kept up to the same scantling as the former. Up to the present time about 50 boilers have been and are in process of construction in accordance with the above, and to enable you to go fully into the question, should you desire to do so, the Society's rules for the construction of iron boilers are attached to this paper. (*See* Appendix B.)

There is one point in them, however, to which I desire to draw your attention: the Society have adopted a varying contract in their formula for strength of casing plates, whether the material used be iron or steel.

Experience has so far taught them, that the length of life of the casing is longer than any other portions of a boiler, and that on the removal of the latter on account of the inner portions being worn out, the casing plates have been found to be in good condition.

With a view the better to equalize this they now allow a higher constant for thicker plates than for thinner ones, on the grounds that if a $\frac{3}{4}$-inch plate loses one-sixteenth of its thickness from oxidation or other causes, the loss is only $8\frac{1}{3}$ per cent. of its original thickness, whereas in the case of a $\frac{1}{2}$-inch plate it would amount to $12\frac{1}{2}$ per cent.

The Board of Trade has also somewhat reduced the scantling of casing plates in iron boilers, but as regards the introduction of steel plates, the Board of Trade has hitherto taken each case on its own basis, and made it a subject for special arrangement, whilst the Admiralty has in the few instances in which this material has been introduced in the construction of boilers for the Royal Navy only reduced the thicknesses below those required for iron plates by a very small amount. It is not, however, surprising that the Admiralty is cautious; in fact, looking to the peculiar character of the services on which the vessels are employed, such action is only prudent in view of the present uncertain knowledge as to the relative durability of the two materials.

Lloyd's Committee are carrying out another series of experiments as to the relative corrosion of iron and steel plates, each specimen weighed correctly to the $\frac{1}{50000}$th part of its weight. They consist of six series of steel and iron discs obtained from ten of the principal iron and steel manufacturers in the Kingdom. Each disc is $4\frac{1}{2}$ inches diameter, $\frac{1}{4}$ inch thick. Half of them are turned bright all over, and the remainder have the scale left on them, and they are all weighed accurately. Each series is made up of 22 discs suspended on iron rods, insulated by glass tubes and ferrules, as shown in the one handed round to you.

They are disposed of as follows:—

Series A. Exposed to the action of the atmosphere.
" B. " " sea water.
" C. " " bilge water.
" D, E & F. " " hot water.

and steam in marine boilers worked under various conditions in ocean-going steamers.

The specimens will be accurately weighed at intervals, and the extent of the corrosion correctly recorded. An accurate analysis of each specimen has also been made.

But interesting and instructive as such experiments must be, the durability of the material in practical use in boilers partly or wholly constructed of it can alone solve the problem, whether steel is destined eventually to supersede iron for such purposes.

Thus far our attention has been more particularly directed to what has been and is going on in the commercial marine, and I now desire to call your attention to the modern machinery being introduced into the Royal Navy.

It is between six and seven years ago that Sir Joseph Whitworth drew the attention of marine engineers to his then new material, fluid pressed steel, having a tensile strength of 40 tons to the square inch. The metal is submitted to great pressure, whilst in the fluid state, by which means perfect soundness and homogeneity are obtained; subsequently it is forged to shape by hydraulic pressure. The distinguishing characteristics deservedly claimed for it are soundness, strength, and ductility. It is made of various tempers to suit all purposes, and it is specially adapted to those in which it is exposed to sudden and violent strains. The Admiralty at once decided on trying it for the liners of the high pressure cylinders in compound engines, and the success has been such that they have entirely abandoned the use of cast iron for them, and in some vessels the liners of both the high and low pressure cylinders are made of it. As regards its weight, a cylinder liner made from a hoop of fluid pressed steel and enlarged to size by forging having an outside diameter of $81\frac{1}{16}$ inches, a thickness of $1\frac{3}{4}$ inch, and a length of 59 inches, weights 65 cwts. Amongst the earlier vessels so fitted may be mentioned the following:—

TABLE II.

Name of Ship.	Diameter of Lining.	Length of Lining.
	Inches.	Inches.
"Amethyst"	$55\frac{1}{2}$	44
"Audacious"	77	$46\frac{1}{4}$
"Euryalus"	73	$57\frac{1}{2}$
"Inflexible"	70	$52\frac{3}{4}$
"Iris"	75	44
"	41	$38\frac{1}{3}$
"Mercury"	75	44
"	41	$35\frac{7}{8}$
"Rover"	72	$57\frac{1}{2}$

In the case of the "Audacious," having expansive engines with surface condensers and working with 30 lbs. pressure on the square inch, the liner was fitted to replace the original cast iron one, which had cracked after having been at work for some time, and there has been no further trouble since.

At about the same time Sir Joseph Whitworth urged its adoption for screw propeller shafting, and a forging made from a hoop of it, and forged hollow, having a length of 33 feet $6\frac{1}{2}$ inches, outside diameter $17\frac{1}{2}$ inches, diameter of hole $11\frac{3}{8}$, thus leaving the metal in the body of the shaft $3\frac{1}{16}$ inches in thickness with a diameter of collars (finished) of $33\frac{1}{2}$ inches, weighs 8 tons. Such a shaft made of solid wrought iron in the ordinary way would weigh 13 tons or 60 per cent. heavier than the hollow steel one. Table III gives you the particulars of the shafting belonging to the first five vessels on board which it was fitted.

TABLE III.

Name of Ship. H. M. S.	Total length of Shafting.	Number of Lengths.	Total Weight.	Weight if made of solid Wrought Iron.
	Ft. Ins.		Tons.	Tons.
"Bacchante"	75 $11\frac{1}{2}$	5	19	$29\frac{1}{2}$
"Inflexible"	283 9	14	$62\frac{3}{4}$	97
"Iris"	139 0	7	29	43
"Mercury"	139 0	7	29	43
"Euryalus"	76 $11\frac{3}{4}$	5	$19\frac{3}{4}$	$29\frac{3}{4}$

In the case of the "Inflexible" you will observe that there is a saving in weight in favour of the fluid pressed steel shafts of 34 tons, an amount of weight of very considerable moment in heavily armoured plated ships.

Sir Joseph Whitworth is now directing his attention to the construction of connecting shafts or crank axles; his idea at present appears to be to make them in pieces and then screw all together. Valuable as this material has shown itself to be, I am not aware of its having been introduced in any one case into the commercial marine; although more costly than iron, considerable weight would, by its adoption, be saved, and continuously carrying extra weight involves the continuous consumption of more coal.

At the "Great Western" Steamship era to which I have alluded, the steam fleet of Great Britain consisted of 66 paddle-wheel vessels, of which 28 were employed at home in the post office service. For its present condition I must refer you to the last number of the Navy List, but I may mention that a corvette has done her $18\frac{1}{2}$ knots in Stokes Bay, and after nearly 18 years surpassed the speed of the "Leinster" and "Connaught," two of the present Holyhead mail steamers, by half a knot per hour, and that the consumption of coal on board our heavy ironclads has been reduced to a rate of con-

sumption per indicated horse power equal to anything yet accomplished afloat.

Two small but very important additions have within the last few years been fitted in all vessels belonging to the Royal Navy. In the first place I allude to the self-acting hanging non-return valve, introduced between all boilers and their main stop-valves, with the object that if the boiler should from any cause become injured and its own steam escape inboard, no steam from any one of the other boilers should be able to enter it through the steam pipes, thus preventing any addition to the volume of steam the injured boiler originally contained, and reducing risk under this head to a minimum. The value and efficiency of such valves has been clearly demonstrated. The second addition is the introduction of what are called "change "valves." It was considered that it would be highly advantageous that in all unarmoured vessels on board which the boilers are worked at high pressures, for obvious reasons the Officer in command should be enabled to take his vessel into action at pressures of steam, say from 10 lbs. to 20 lbs., or even less, and this has been carried out by the introduction of valves, by the opening and closing of which the engines cease to work on the compound system, and steam in the boilers being reduced to these low pressures it is admitted directly into the low pressure cylinders. As this has been carried out by more than one arrangement, I deal with it in my description of the machinery in some of the vessels belonging to our Royal Navy, the principal dimensions of which will be found in Appendix C, and I propose to begin with the "Iris."

H.M.S. "Iris."

This steel despatch vessel, of 3,735 tons and 7,000 indicated horse power (as described in the Navy List), is fitted with twin-screw engines (Plate XXIV), which were designed and manufactured by Messrs. Maudslay, Sons, and Field, and consist of two pairs of horizontal compound engines, each pair being placed in separate watertight compartments, forming two distinct engine rooms. Each pair of engines has its own line of propeller shafting as in ordinary cases.

These engines, besides being fitted with all the most modern improvements, have in addition an arrangement of valves and pipes, by which steam from the boilers can be used direct in all the cylinders, so as to be enabled to work them with steam of very low pressure on all the pistons (see Plate). This arrangement was suggested in consequence of the very great advantage that it was considered an unarmoured vessel like the "Iris" would derive from being able to go into action with steam in the boilers of only a few pounds' pressure above that of the atmosphere, and it was estimated by Messrs. Maudslay that about two-thirds of the ultimate speed of the vessel might be obtained by this arrangement with steam in the engines at the atmospheric pressure. This, in the case of the "Iris," would be a speed of from 12 to $12\frac{1}{2}$ knots per hour.

As saving of weight was a great object in these engines, wrought iron was used as much as possible in the framing and guides, and the

lines of propeller shafting were made, where advisable, of Whitworth's fluid compressed steel, whilst the barrel parts of the boiler casings were made of the Landore Company's mild steel, similar in quality to that of which the vessel is built.

The engines have in all eight cylinders, four high pressure and four low pressure. The high pressure cylinders are bolted on to the front of the low pressure ones, and partly recessed into them; this arrangement reduces the length of the engines on the athwartship lines of the vessel, and at the same time the cover of each cylinder can be taken off, and the pistons examined and overhauled without the removal of the high pressure cylinders. Each engine is also complete in itself, and can be used as a single engine in case of any accident happening to the other. The slide valves of each set of high and low pressure cylinders are worked by the same eccentrics and link motion, the high pressure cylinders being also fitted with a separate expansion valve working on the back of the slide valve, receiving its motion by a separate eccentric, and slotted levers for regulating the amount of expansion.

The space for the machinery being very limited, the surface condensers and air-pumps have been placed in the wings behind the cylinders. They are constructed to suit the form of the vessel, and are made entirely of brass. The air-pumps stand vertically, and are single acting, one to each set of engines, 43 inches diameter, with a stroke of 21 inches; they are worked by means of bell-crank levers, with rods passing direct from the foremost low pressure piston of each set. The cold water is circulated through the condenser by two centrifugal pumps 3 feet 9 inches diameter, driven at about 120 revolutions per minute by small independent engines. These pumps are arranged also for pumping out the water in case of accident as bilge pumps, and are capable of discharging 500 tons of water per hour.

The boilers are twelve in number, placed also in two different watertight compartments, six in each compartment; these, like the condensers, are made of different form and size to suit the space in the vessel; they are placed in the wings with the stokeholes amidships. There are two fixed funnels, that for the forward set of boilers being 7 feet 7 inches diameter, and that for the after set being 8 feet 4 inches diameter.

The screw propellers as originally fitted were four-bladed, with a diameter of 18 feet 6 inches. With these propellers set at 18 feet 2 inches pitch, and the engines working up to 7,502 indicated horse power, with 91·15 revolutions per minute, a speed of vessel of 16·577 knots was obtained. This speed not being considered satisfactory, the vessel was tried with two of the blades removed from each propeller, the engines being worked up to as much power as was considered safe to transmit through the remaining blades; this trial gave a very considerable increase of speed in proportion to the power exerted, the speed being 15·726 knots, with 4,369 indicated horse power; but as the propellers in this condition caused an excessive vibration in the vessel, it was determined to try two new four-bladed propellers of reduced diameter, namely 16 feet 3 inches. With these propellers set

at a pitch of 20 feet, a speed of 18·572 knots was obtained, the engines working up to 7,713 indicated horse power, with 97·18 revolutions per minute, thus adding nearly 2 knots to the speed, with an addition of only 211 horse power. At the same time it was determined to try two new two-bladed propellers of sufficient area and strength to transmit the whole power of the engines through them; these were made 18 feet 1½ inch diameter with a pitch of 21 feet 5 inches, and on trial gave a result of 18·587 knots per hour, with an engine power of 7,463 horses, which it will be seen is a still higher speed compared with the power exerted than was obtained with the new four-bladed propellers; but in this case, as in the former experiment with the two-bladed screws, the vibration of the vessel was so excessive, that the four-bladed propellers of the reduced diameter were finally adopted.

For the sake of ready comparison, these results are shown in the following table:—

TABLE IV.

Date of Trial.	No. of Blades	Diameter of Propeller.	Pitch of Propeller.	Revolutions per Minute.	Indicated Horse Power.	Speed of Vessel in Knots.	Slip of Propeller per cent.
1878		Ft. Ins.	Ft. Ins.				
4 Feb..	Four	18 6½	18 2	91·15	7,502	16·577	1·5 neg.
15 „ .	Two	18 6½	18 3	88·88	4,369	15·726	1·8 pos.
3 July.	Four	16 3	20 0	97·18	7,713	18·572	3· „
Aug..	Two	18 1½	21 5	93·	7,463	18·587	5· „

The total weight of machinery, including two auxiliary pumping engines with water in the boilers and surface condensers, but exclusive of spare gear, is 968 tons.

The arrangement of change valves adopted by Messrs. Maudslay, Sons, and Field, is one patented by Mr. Sells of that firm in 1876, and can be applied to compound engines made with two or four cylinders. By it the high and low pressure cylinders, besides being worked in the usual expansive way, can, if so desired, be directly supplied with steam from the boilers, and directly discharge their exhaust into the condenser by an arrangement in connection with the cylinder valves, by means of which the passage between the eduction of the high pressure cylinder and the low pressure slide jacket can be closed and a communication opened between the low pressure slide jacket and the main steam pipe, so that when it is desired to work with a considerably reduced pressure of steam in the boilers, both the high and low pressure cylinders are supplied with steam at the same pressure, and the eduction from both is led into the condenser, the engines being thus worked as ordinary coupled engines and the combined areas of all the cylinders being utilized.

In order that the working of the engine or engines may be readily changed from that of a compound engine, or a pair of compound engines, to that of a simple double cylinder engine, or pair of double

engines and conversely, duplicate passages and pipes are provided from the eduction of each high pressure cylinder, one of these leading to the valve chest of the low pressure cylinder and the other leading to the condenser. Duplicate passages are also provided to the supply of each of the low pressure cylinders, one of these leading from the eduction of the high pressure cylinder, and the other from the steam pipe. Each of these passages is provided with a shut-off valve, or each pair may be provided with a duplex valve, whereby, when the one of the pair is opened, the other is closed.

When the engine is to be worked as a compound engine, the valves are set so that the steam discharged from the high pressure cylinder passes to the low pressure cylinder, whence, after having done its work, it is conveyed to the condenser; but when the engine is to be worked as a simple double cylinder engine, the valves above mentioned are altered, so that the steam discharged from the high pressure cylinder passes directly to the condenser, and the low pressure cylinder receives its steam directly from the steam pipe, discharging as before into the condenser.

Plate XXIV,[1] Fig. 1, represents a section through the low pressure valve casing with both cylinders on the same axis. *A* is the high pressure cylinder and *B* the low pressure cylinder having the slide facing *C*; *D* is the exhaust pipe from the high pressure and *E* the exhaust pipe from the low pressure cylinder; *F* is a branch from the main steam pipe; *G* is a duplex valve which can seat either, as shown in Fig. 1, in which case the exhaust from the high pressure cylinder flows by the pipe *E* to the condenser; *H* is a shut-off valve which when seated, as shown, prevents the supply of steam from the main steam pipe to the low pressure cylinder, but which can be opened so as to supply steam thereto when the valve G is moved to *g*.

Fig. 2 is a sectional plan of the cylinders *A* and *B* of a compound engine, placed side by side, showing an arrangement of valves for such engines. *C* is the low pressure slide jacket; *D* is the discharge passage from the high pressure cylinders; *E* is the exhaust pipe leading to the condenser, and *F* is the steam pipe from the boilers; *G* is a duplex valve whereby the exhaust from the high pressure cylinder can be permitted to flow into the reservoir supplying the low pressure cylinder, or can be made to pass to the condenser when the valve *G* is moved to *g*; *H* is a shut-off valve, which either cuts off or admits steam from the steam pipe to the low pressure reservoir.

The next vessel whose machinery I draw attention to is the "Inflexible."

H.M.S. "Inflexible."

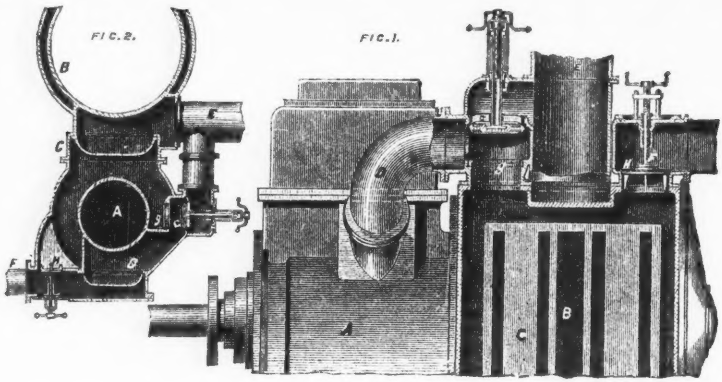
The "Inflexible," of 11,406 tons and 8,000 indicated horse power, according to the Navy List, is fitted with twin-screw engines, by Messrs. John Elder and Co., of Glasgow, and each pair stands in an engine room separate and distinct by itself, the two being separated

[1] The Institution is indebted to the proprietors of "The Engineer," for the reproduction of this plate.—Ed.

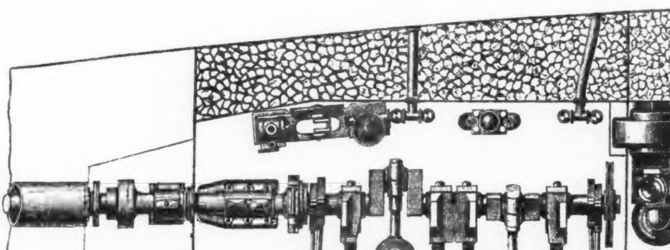
Journal R.U.S. Institution.
Vol. 23.

Arrangement of Charge Valves.

H. M. S. "I

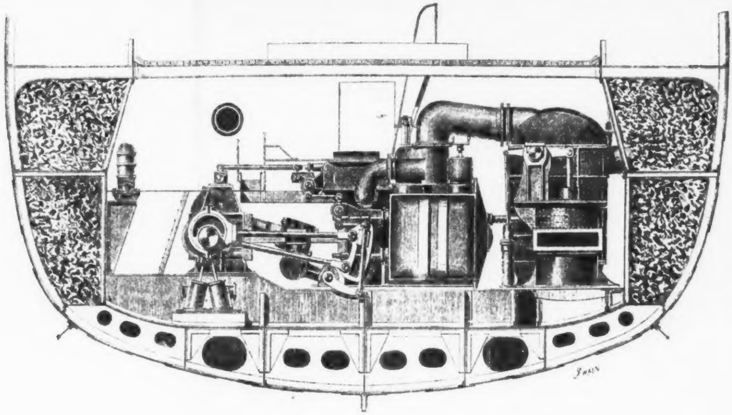


Plan of Engine R

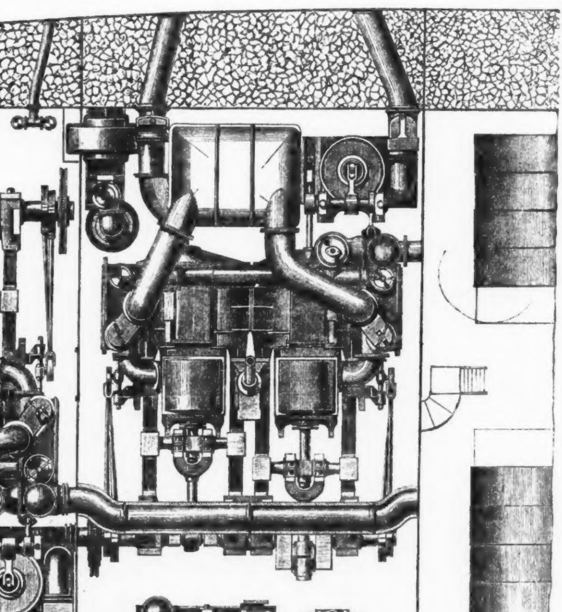


Harrison & Sons, Lith. St Martins Lane, W.C.

(From The Engineer by



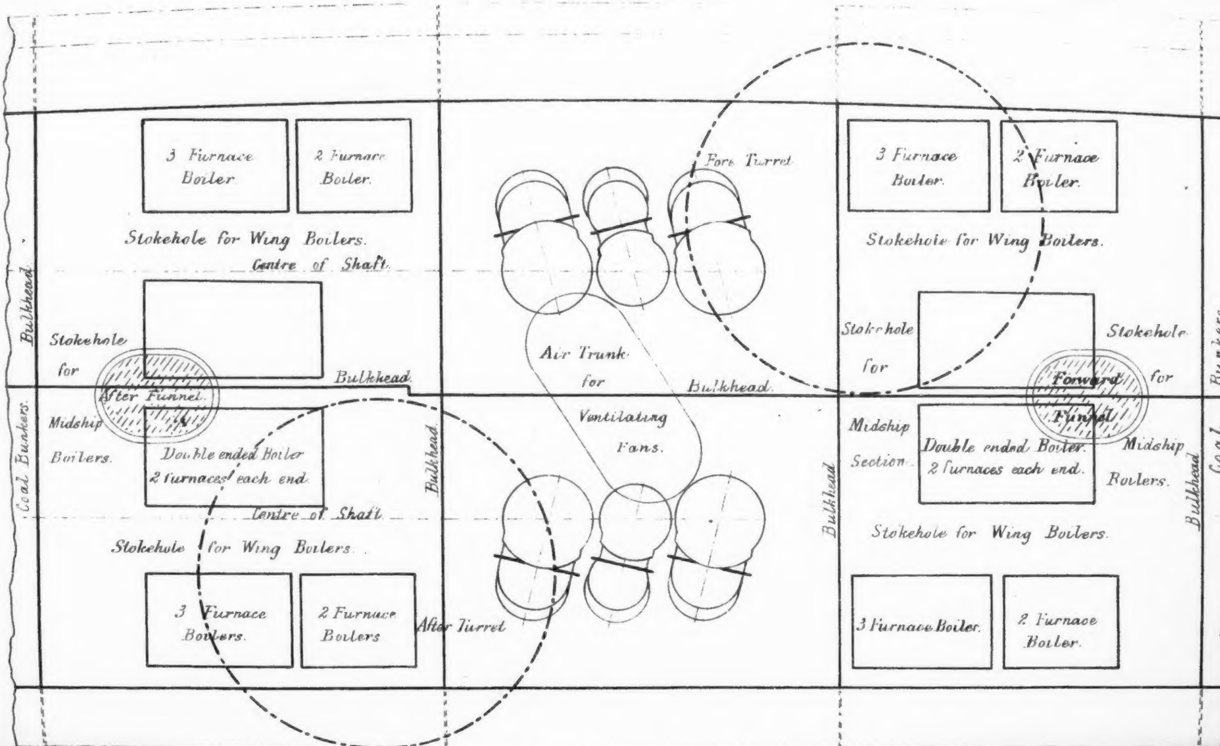
of Engine Room.



e Engineer by permission)

H. M. S. "INFLEXIBLE." Plan of Engine and Boiler Rooms

Scale 1/16 inch = 1 foot.



by a longitudinal watertight bulk-head with watertight doors fitted in it running along the centre line of the ship.

The arrangement of the stoke-holes (four in number) differs from that on board any other iron-clad vessel in the Royal Navy, two of them being forward and two abaft of the engines, and in each stoke-hole there are three boilers, making twelve in all. The engines are of the compound type, having three cylinders, one high and two low pressure.

The working barrels of the cylinders are cast separately and distinct from the casings, the barrel of the high pressure cylinder being made of Whitworth's fluid compressed steel, and those for the two low pressure cylinders of cast iron.

Each piston has two piston rods 7 inches in diameter with one cross-head common to both.

The slide valves are of the piston type with cast iron packing rings, and are worked by Gooch's gear, which gives a constant lead to all grades of expansion. An expansion valve is also fitted to each cylinder having ports round the valve chambers, and is worked by a vibrating motion.

The engines are reversed by means of a steam cylinder fitted with an hydraulic break assisted by a starting valve, from which steam passes into the low pressure valve casings. The steam after passing through the high pressure cylinder passes into the low pressure cylinders, whence it is exhausted into two independent surface condensers.

The surface condensers are also fitted with a common injection pipe, and so arranged that they can be worked as common condensers. Each condenser has its own independent air pump, 34 inches diameter with a length of stroke of 2 feet 3 inches, worked by levers from the piston cross-heads. The circulating water is forced through the tubes of the condensers by a centrifugal pump worked by a separate engine. It is also fitted as a bilge pump, being placed at a high level in the engine room for the purpose of pumping the water out of the ship in the event of emergency arising, separate connections being fitted to the pump for that purpose. Each set of engines is fitted with two feed and two bilge pumps, each $7\frac{1}{2}$ inches diameter and 2 feet 3 inches length of stroke, worked from the air pump levers.

The crank shaft is of wrought iron, made in three pieces coupled together, and the cranks are placed at an angle of 120 degrees to each other. The thrust block is of cast iron, fixed to the foundation plate; the thrust being taken in the usual way on brass collars. The propeller shafting is hollow and is made of Whitworth's fluid compressed steel.

The boilers (Plate XXV), are arranged in four separate compartments—two before and two abaft the engine room; the funnels are placed at the extreme ends of both the fore and aft boiler rooms to suit the requirements of the turret arrangements. The arrangement of engines and boilers, which is special to this ship, was adopted for the purpose of getting the whole of the machinery within the armoured citadel, and although this arrangement of machinery is novel, there was on the six hours' full power trial as good a supply of air to the furnaces, and as good ventilation in the engine and boiler rooms

generally, as any ship in the Service. This is proved by the fact of the large power obtained during the six hours' trial without any steam blast being used.

The boilers, twelve in number, are of an oval shape having flat sides, and of three different sizes. The four smallest boilers, in addition to their connections to the main steam pipe, are fitted with a separate set of steam pipes for supplying the auxiliary engines with steam.

At the six hours' official trial on the 14th November, 1878, at Portsmouth, the average indicated horse power exerted was 8,487, with $73\frac{1}{4}$ revolutions per minute, and with a pressure of steam of 61 lbs. on the boilers, and the maximum indicated power attained during the run amounted to 8,909 horses, the average consumption being 2·06 lbs. of coal per indicated horse power per hour.

The use of piston slide valves is not altogether new in engines of the Royal Navy. Thirty years ago they were fitted in the 4-cylinder engines constructed by Messrs. Maudslay, Sons, and Field for the Royal Navy, as also in the engines of the "Basilisk" 400 horse power paddle wheel frigate, and the Holyhead Mail Packet "Llewellyn" by Miller, Ravenhill and Co., but were abandoned at that time by both firms in consequence of the difficulty of handling them, neither steam nor hydraulic pressure having at that period been applied to the starting gear of marine engines, a system now some years since introduced into large engines in the Royal Navy as also into those in the commercial marine.

H.M.SS. "Nelson" and "Northampton."

I follow on with the sister ships, "Nelson" and "Northampton."

The "Nelson," of 7,323 tons and 6,000 horse-power, as recorded in the Navy List, is also fitted with twin-screw engines, by Messrs. John Elder and Co., a watertight bulkhead rising from the keel, separating the engine rooms on the fore and aft line of the vessel. The engines are of the 2-cylinder vertical type, and the shafting is all made of hammered scrap iron.

The official trial of them took place at Plymouth in March, 1878, and at the full power trial of 6 hours' duration the average indicated horse power was 6,246, with 79·05 revolutions per minute, and a pressure of steam on the boiler of 60 lbs. on the square inch; at the half-power trial of 4 hours' duration the indicated horse power was 3,083, with 63·35 revolutions per minute, and a pressure of steam on the boilers of 60 lbs.

The average consumption of coal during the full power trial being 2·14 lbs. per indicated horse power per hour, and during the half-power, trial 1·47 lbs. of coal per indicated horse power per hour. This was also obtained without the use of the steam blast. The above two results are equal, if not superior, to any equally well authenticated performance up to the present time.

But interesting as these recorded facts are, the peculiar novelty in these particular engines is the abandonment of the ordinary heavy cast iron foundation frames. With a view to reducing the weight of

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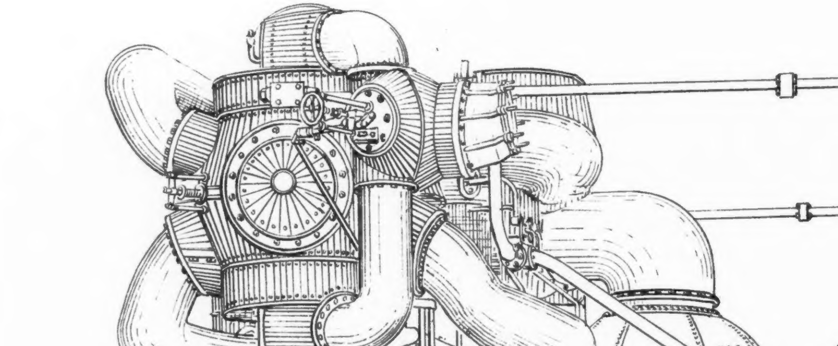

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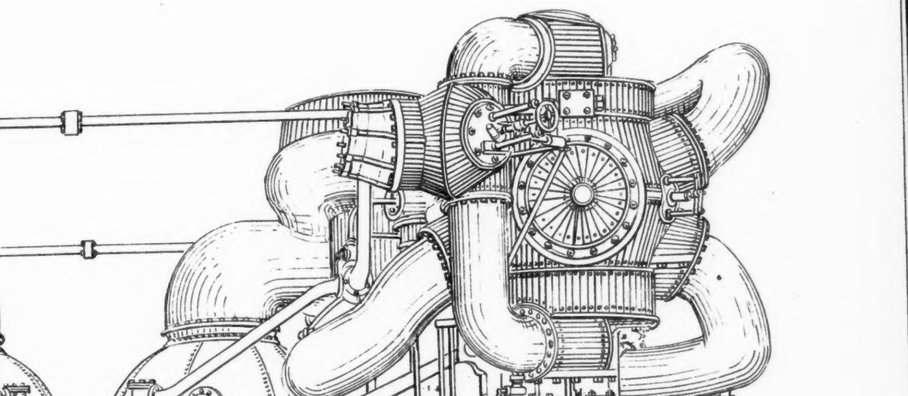

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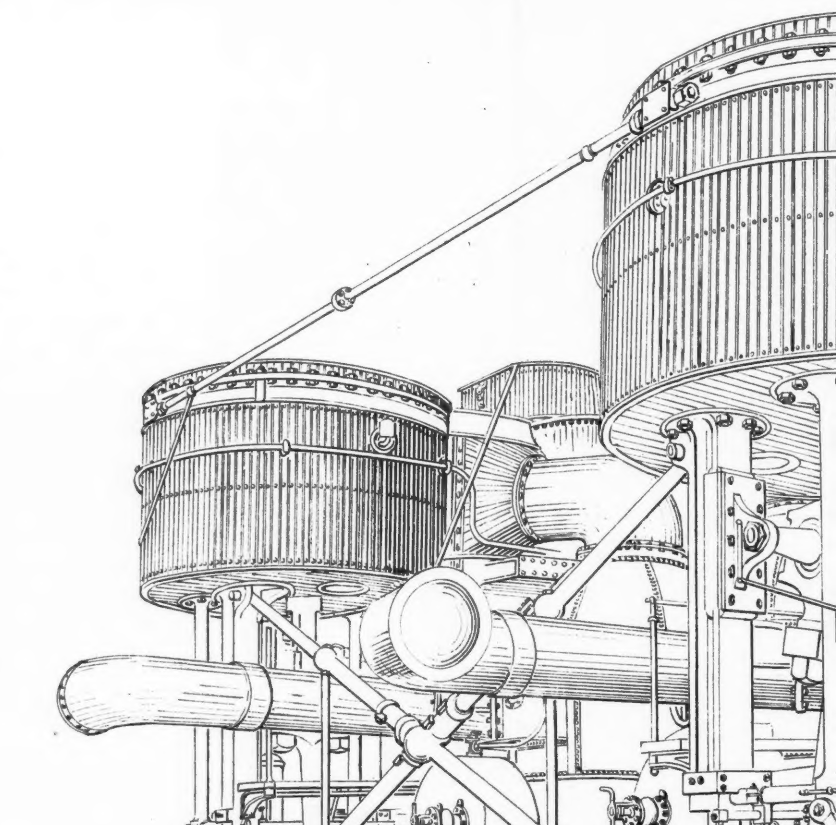

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Pl. XXVII.

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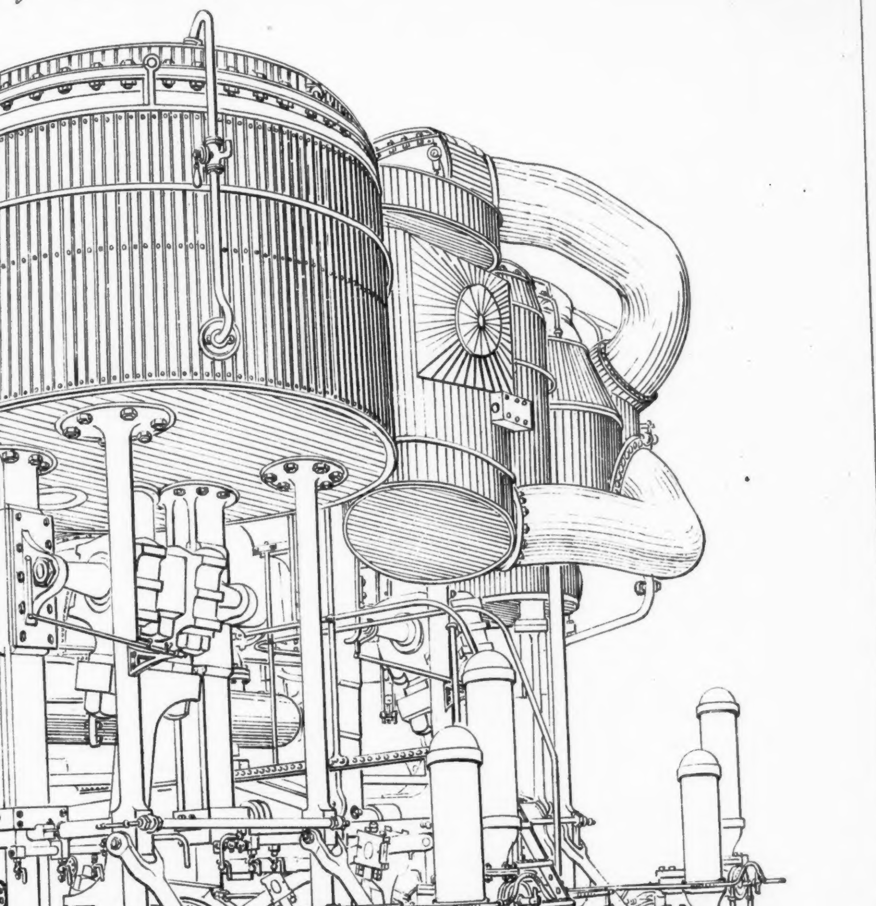

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the engines as much as possible, these heavy cast iron sole frames are dispensed with, and four light forgings to carry the crank shaft bearings and the lower ends of the columns are substituted. These light sole plates are carried by four transverse box girders, the sides of each are built immediately over two of the ship's frames, the frames and superstructure together forming a box girder 38 feet long, 7 feet deep in the centre, and 3 feet 3 inches deep at the ends; the load being principally carried at the centre of the engines, a distance of 12 feet on either side from the centre of the girder. The lateral rigidity of these girders is assisted by inserting brackets between them over the keelsons.

The heavy cast iron vertical frames, on the top of which the cylinders are always placed, are also abandoned, and light wrought iron engine columns and girders substituted; they are trussed diagonally from one engine to the other, and to the transversed girder near their ends. (Plates XXVI and XXVII.)

The machinery of H.M.S. "Northampton" was manufactured by Messrs. John Penn and Son, of Greenwich, and consists of two sets of inverted 3-cylinder engines driving twin-screws. They are of their usual vertical type, fitted with surface condensers. When working at the full power of 6,000 horses, they are simple expansive engines, working with steam of 60 lbs. pressure cut off at about one-fifth of the stroke, and making 85 revolutions per minute. When working, however, at half power the engines are compound engines, the steam from the boilers being admitted into one cylinder only of each set, and expanded simultaneously into the other two before passing into the condenser. The power exerted under these circumstances is 3,000 horses, and the number of revolutions 68. This compound system is also used for any less power than 3,000 horses. The engines may also be worked as simple expansive engines with low-pressure steam. Therefore at these reduced powers (which are those ordinarily used by men-of-war when cruising) the vessel has all the advantages of compound engines in point of economy, &c., while there is an actual gain at very small powers in not having a low pressure cylinder disproportionately large.

You will of course perceive that this arrangement, when working with the three cylinders all taking steam from the boilers, requires no change valves to work with steam of any reduced pressure.

The alteration from one system to another is effected in a few minutes by opening or closing, as may be required, stop-valves placed in the exhaust pipes, and in the pipe leading from the first cylinder to the other two. The change can be effected, if necessary, without stopping the engines.

Each cylinder is supported upon two cast iron columns, which carry the piston rod guides in the usual manner; the three cylinders of each set of engines being tied together by wrought iron rods, which are continued to the transverse bulkheads of the ship to prevent derangement when ramming. Each cylinder has a double-ported slide on the equilibrium principle, and an expansion slide working at the back of it, so fitted as to cut off the steam at any point between $\frac{1}{10}$ and $\frac{6}{10}$

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The alteration from one system to another is effected in a few minutes by opening or closing, as may be required, stop-valves placed in the exhaust pipes, and in the pipe leading from the first cylinder to the other two. The change can be effected, if necessary, without stopping the engines.

Each cylinder is supported upon two cast iron columns, which carry the piston rod guides in the usual manner; the three cylinders of each set of engines being tied together by wrought iron rods, which are continued to the transverse bulkheads of the ship to prevent derangement when ramming. Each cylinder has a double-ported slide on the equilibrium principle, and an expansion slide working at the back of it, so fitted as to cut off the steam at any point between $\frac{1}{10}$ and $\frac{6}{10}$

of the stroke. The main slides are worked by link-motion in the usual manner, and steam starting-gear is fitted in order that the engines may be reversed as rapidly as possible. The alteration of the cut-off of the expansion valves is effected by hand-gear, and it is not necessary to interfere with this gear when stopping or reversing the engines.

An important advantage claimed by the makers of these engines from the three cylinders being equal, and from the cranks being placed at equal angles, is an extreme evenness of motion at slow speeds arising from their perfect balance. This will be appreciated by those who have seen unbalanced 2-cylinder compound engines driven slow.

It may be added that in any case where weight is of great importance, it would be easy to replace the cast iron columns and frames used in the "Northampton" by wrought iron or steel, by which, no doubt, a considerable saving of weight would be effected.

The vessel came round from Glasgow to Plymouth under her own steam. She has since been under weigh on trial, and her machinery has been accepted by the Admiralty. So soon as she is commissioned, it is proposed that a series of trials should take place to test her consumption of coal at various speeds, and, I need scarcely add, these are looked forward to with great interest.

H.M.S. "Shannon."

I now come to H.M.S. "Shannon." She is an armour-plated frigate, described in the Navy List as of 5,439 tons and 3,378 indicated horse power, and was the first vessel in the Navy fitted with *change valves*, which were decided to be introduced during the construction of her engines. Her engines, made by Messrs. Laird Brothers of Birkenhead, are of the usual horizontal type, having four cylinders, two high pressure ones and two low pressure, with surface condensers.

On their official trial the engines exerted an indicated power of 3,542 horses, with an average of 65 revolutions per minute.

Plate XXVIII shows you a section through her main slide and expansion slide valves, and it requires no explanation from me. The change valves are in point of fact stop valves, and are so arranged that when steam is to be used of a reduced pressure, it acts only on the larger pistons of the low pressure cylinders, whilst the small pistons are moving backwards and forwards in steam common to both sides of them.

The "Comus" Class.

These vessels are constructed of steel and iron cased with wood, of 2,383 tons as per the Navy List, and 2,300 indicated horse power. The "Comus," "Champion," and "Carysfort" were built and engined by Messrs. John Elder and Co.

The screw propeller of the "Comus" is driven by a set of horizontal compound engines with return connecting rods. The engines have one high pressure and two low pressure cylinders, and are so arranged as to be capable of being converted into simple engines to work at

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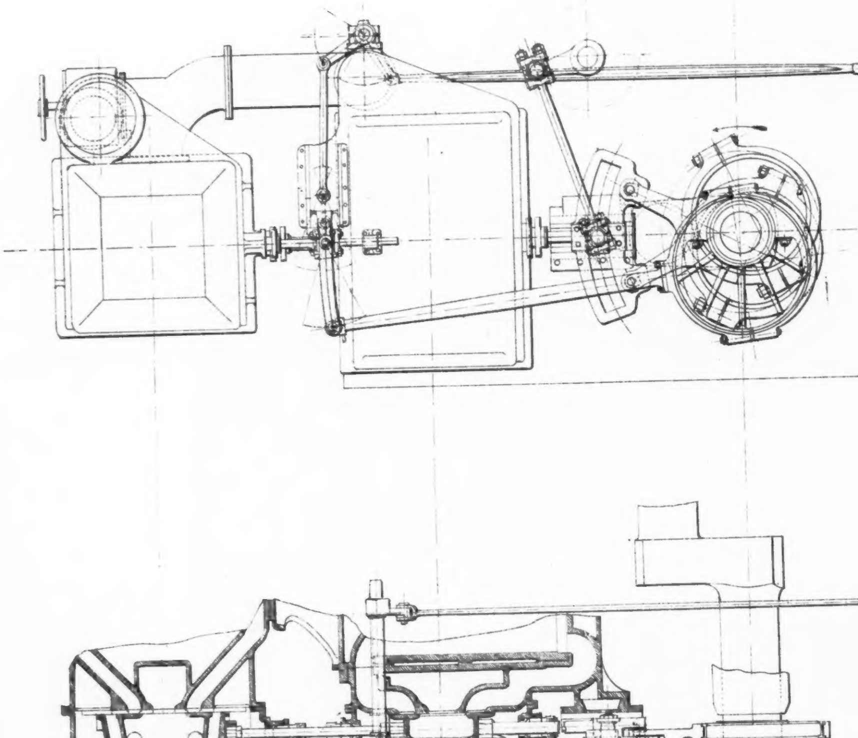
Arrangement of Slide and Expansion Valves



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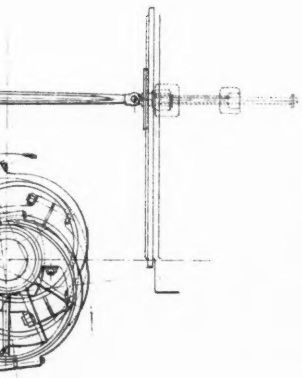
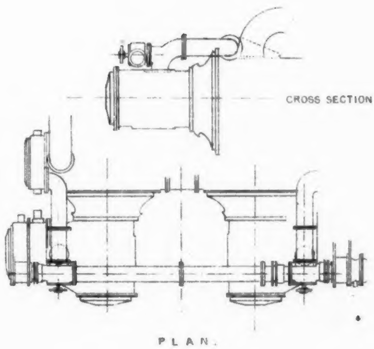
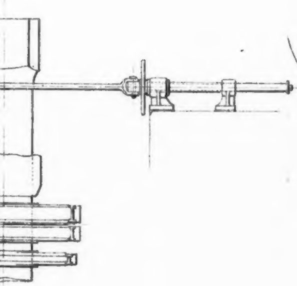
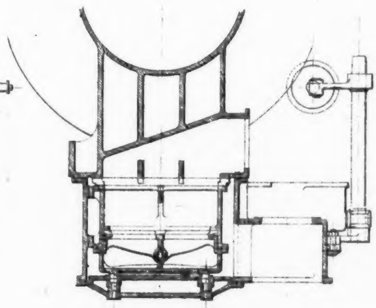




Arrangement of Steam Pipes in Engine Room.





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30 lbs. on the square inch or under, by means of a separate flat-faced valve (or change valve).

The high pressure slide valve is placed on the forward side of its respective cylinder, is flat-faced, and driven directly from the crank shaft by means of eccentrics and the ordinary link motion. The valves of the low pressure cylinders are placed on the top of them, receiving their motion from eccentrics, and link motion through an intermediate or weigh shaft and levers. The slide valves of all three cylinders are single ported, and are fitted with balance rings on the back of them for the purpose of relieving the pressure.

The usual expansion valves are dispensed with, and none are fitted, but when it is desirable to alter the rate of expansion this can be done by "linking up" all the valves at the same time; as is well known the opening of ports for the admission of steam is often very much reduced when working "linked up;" to obviate this, the ends of each valve have an extra port for the admission of steam, these ports being so arranged as to open on to the face at the lap portion of the valve, the admission of steam being controlled by fixed plates attached to the slide valve casings.

The engines are changed from compound to simple, and *vice versâ*, by means of a flat-faced slide valve placed inside a chest, having ports with connections to the low pressure valve casings and to the condenser, the change being effected by removing the valve along the face and thus uncovering the communication from the boilers to the low pressure valve casings, still leaving the communication open to the high pressure cylinder, thus making the steam common to all the cylinders, and at the same time covering the high pressure exhaust connection to the low pressure casing, and opening a direct communication with the surface condenser. Before changing the engines from compound to simple they must be stopped, and the boiler pressure reduced from 60 lbs. on the square inch to 30 lbs., or any lower pressure desired, and while this is being done, the "change valve" is moved as above described. The time required to effect this was found to be in the case of the "Comus" only four minutes, so that the time from working compound to again working as simple engines was not more than five minutes, and the engines made at full speed $96\frac{1}{2}$ revolutions per minute, and exerted on their official trial an indicated power of 2,406 horses.

The propellers of the "Comus" and "Champion" are fitted to lift on the usual method adopted in Her Majesty's Service; the propeller of the "Carysfort" is of the feathering description, also with two blades. The feathering gear of the "Carysfort" is enclosed in the propeller boss, which is slightly enlarged for that purpose, and is actuated from the inside of the ship by a shaft passing through the stern shaft, which is hollow, having on the inner end of it a worm, which is worked by a small worm contained in the aftermost coupling. On the outer end of this internal shaft is keyed a double-ended lever, and the stems of the propeller blades have each a lever cast with it; the connection between the double-ended levers and those on the propeller blades is effected by means of links having "ball and socket"

joints; this kind of joint being necessary on account of the angular motion of the different levers not being in the same direction to each other. When it is required to feather the blades, the engines are stopped with the propeller blades vertical, and kept in this position by the friction break; then by turning the small worm with a ratchet lever, motion is given to the inner shaft, lever and links; and the blades thus feathered. The motion is sufficient to alter the blades from the working pitch to a fore and aft position.

The hulls of the "Cleopatra," "Conquest," and "Curaçoa" were also allotted to Messrs. John Elder and Co. for construction, and their machinery to Messrs. Humphrys, Tennant, and Co., of London; the engines are on the horizontal system, and the cylinders are four in number, two high pressure and two low pressure. At the official trial of the "Cleopatra," the engines made 108 revolutions a minute, and developed an indicated power of 2,616 horses. The "change valves" as fitted are an arrangement of the ordinary stop valves.

Torpedo Vessels.

The two firms engrossing most attention at the present time as constructors of *torpedo vessels* and their machinery, are Messrs. Thornycroft and Co., and Messrs. Yarrow and Co.; a paper was read at this Institution about two years ago by a member of the first-named firm, and the author regrets that he has not received any information from them for this paper.[1]

Messrs. Yarrow and Co., of Poplar (Plate XXIX), drive the propeller only (which is of the ordinary form) with the main engines, and fit an auxiliary pair for working the air pumps. The former have inverted cylinders on the compound system, bolted together, standing on columns attached to the cast iron foundation frame; the slide faces on the cylinder are of iron, but cast separately, and are pinned on; the slide valves are of brass; all the moving parts usually made of wrought iron are of Bessemer steel, with holes drilled through the larger ones with the object of saving weight; the propeller is forged of steel subsequently tooled up and finished accurately to the dimensions required. The diameter of the high pressure cylinder is $12\frac{1}{2}$ inches, that of the low pressure is 22 inches, with a length of stroke of 12 inches, and when running at their greatest speed the engines make about 500 revolutions per minute, the steam gauge indicating 130 lbs. pressure of steam. The surface condenser is circular, and made of copper. The tubes are of brass, and are placed horizontally, the water passing through them. The boiler is of the locomotive type, the casing being made of steel plates, the furnaces either of copper or of Lowmoor iron, and the boiler is always proved by hydraulic pressure to double the working one on the square inch prior to being set to work. Following the French system, they have a hole drilled through all their screw stays, so that in the event of a stay giving way in the body when steam is up, the leak at once shows itself. The furnace is dependent for its supply of air on a fan blast. In all vessels fitted by this firm they introduce the improvement patented by Mr. Yarrow in

[1] *See* Journal, Vol. xxi, page 611, *et seq.*

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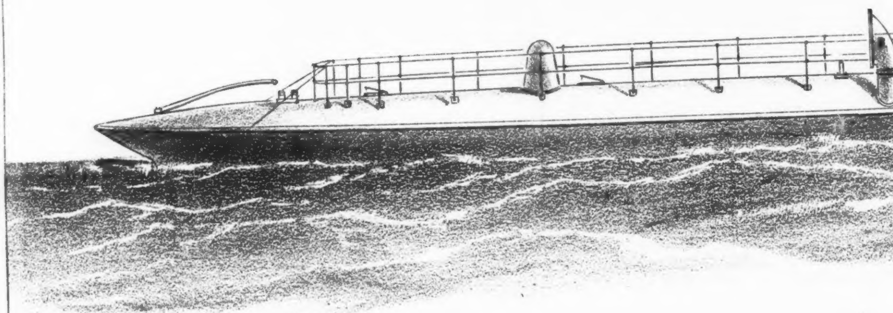

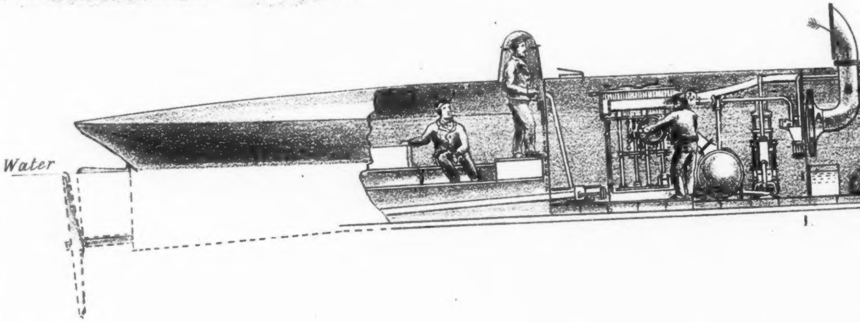

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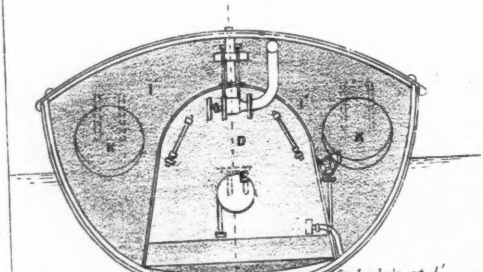

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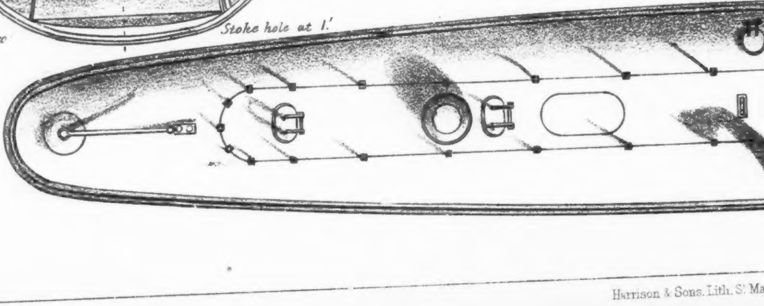

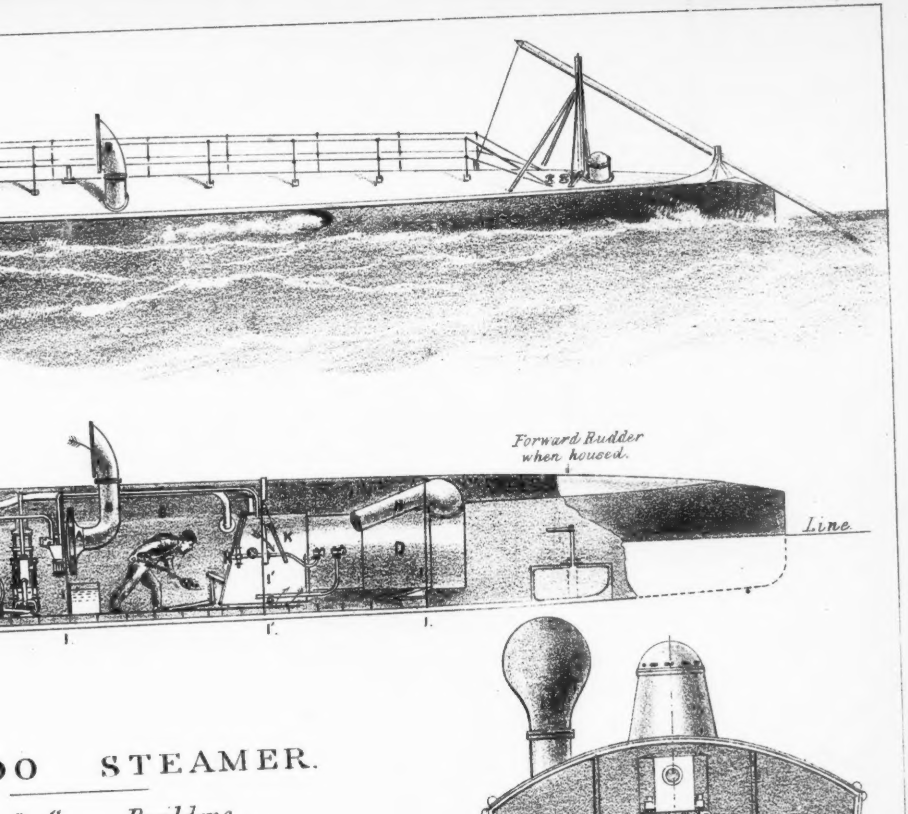

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August, 1878, which has for its object the security of immunity from danger to the engineers when on duty in the event of a failure occurring in some portion of the boiler or boilers, such as the bursting or fusing of some of the tubes, &c. Trouble has been experienced in consequence of this latter occurrence taking place in some torpedo vessels belonging to foreign Governments. This improvement is obtained by the introduction between the fan which supplies the forced draught and the furnace of valves so arranged, that whilst they allow the air to pass freely to it from the fan act as non-return valves to any current of air or steam that may attempt to pass through them in the opposite direction.

The fan A is driven in any suitable manner so as to draw air from the external atmosphere through a pipe B, and direct the same into the stokehole C; D is the boiler, and E is the furnace with the fire door F, and ash-pit at G. Bulkheads are provided at I, I, and I′, the central one I′ is thus interposed between the fan A and the fires at E, and in this central bulkhead openings are formed which are fitted with valves K, arranged in such a manner as to be opened by the air to allow it to pass freely in the direction indicated by the corresponding arrows from the fan to the fire, but to be closed by a current in the opposite direction. The fire door is arranged to close by its own gravity, so that it may be always closed unless opened at the will of the stoker by a treadle motion. By means of this arrangement any current taking place in the opposite direction to the arrows from the sudden egress of steam or flame gases, the valves will immediately close.

In some of the last new vessels they have abandoned the ordinary arrangement of standing funnel or funnels; the smoke box is connected with uptakes leading to both sides of the vessel in which dampers are fitted, and the smoke and gases are emitted through either the larboard or starboard one as occasion may require, the object being to do this on the *lee* side as far as practicable in approaching an enemy, and in their latest vessels this arrangement is carried right aft to enable the smoke, &c., to pass out at the stern of the vessel.

They have also introduced a second rudder which acts simultaneously and by the same gear with the one at the stern; it is placed well forward in the vessel, only about 10 feet from the stem. When at work it projects below the keel, and experience shows it affects the turning powers of the vessel in a very marked degree, as the latter can turn in a circle having a diameter of from 3 to $3\frac{1}{2}$ times its own length. When not at work, or the vessel has to take the ground, this forward rudder is drawn up into a kind of well, built in the vessel for it, and in which it can be examined at any time at the desire of the Officer in command.

One of these vessels fitted on this system recently, when out on trial, performed a figure of 8 across the tide at high water about two-thirds flood, opposite the Houses of Parliament above Westminster Bridge, the number of revolutions of the engines at the time indicating a speed of vessel of about 15 knots an hour.

In a torpedo vessel 86 feet long, Messrs. Yarrow have obtained the high speed of a trifle over 21 knots per hour at the measured mile; the machinery exerted an indicated power of 500 horses, and the total

weight of it, including water in the boiler, was 13 tons, being ·52 of a cwt. per indicated horse-power. On the 19th of March a higher rate of speed was obtained at an official trial, in Long Reach, of a vessel 86 feet long, 11 feet beam; the mean of 6 runs gave an average speed of 21·93 knots; the best pair of runs gave 22·25 knots, with a maximum revolution of 540 per minute, and a pressure of steam of 124 lbs. on the square inch, and this extraordinary result was obtained with a steel screw, 4 feet 4 inches diameter, 5 feet pitch.

The great objection to the form of boiler of the locomotive type for use in torpedo boats is its weight and the risk involved in a sea-way owing to the fluctuations of the water level, which may momentarily expose a portion of the tube ends or fire-box top to the action of the flame without being covered with water, and the experiments being conducted at Portsmouth with the Herischoff type of boiler have recently attracted attention. The boiler casing, as you know, contains a coiled spiral tube, and is a water-tube boiler.

Messrs. Yarrow and Co. are also about to introduce a form of water-tube boiler which appears to possess some good qualities, but which Mr. Yarrow tells me has not been sufficiently tested to pronounce it free from defects, which may possibly be found only after long usage.

The main features of the boiler are that the tubes are filled with water. A circulating pump is provided to keep on a constant supply of water through all the tubes.

The boiler appears to be very compact and light, and I have myself seen steam got up to 80 lbs. per square inch in between seven and eight minutes.

One essential feature in a good boiler no doubt is facility of repair, and that is one of the main points Messrs. Yarrow and Co. have had in view in designing this boiler. At present only one such boiler has been made by them, of about 25 indicated horse-power, which has run about 1,000 miles, using Thames water, without any apparent difficulty in maintaining steam, and without any trouble having been experienced with it.

I simply draw attention to these boilers as pointing to the direction in which improvements in the future may be made.

The results obtained in the "Lightning" and other early torpedo vessels led the Admiralty to determine to try such machinery on a large scale, and the following description will be interesting to you:—

H.M.S. "Polyphemus."

H.M.S. "Polyphemus" is a ram building of steel of 2,640 tons, and to be propelled by double screw engines of 5,500 indicated horse power, at the present time being constructed by Messrs. Humphrys, Tennant, and Co. The engines are of the horizontal single piston rod type as usually made by that firm, each pair of engines having their high and low pressure cylinders. There are to be no expansion valves, and everything about the engines is, as far as possible, schemed for simplicity and saving of weight, therefore in this case the old practice

of the double throw shaft with three bearings is resorted to, consequently it will be made in one piece. The piston rods, slide valve rods, and all bolts will be made of steel. The inboard propeller shafting will be made hollow, and of Whitworth's fluid compressed steel. The surface condensers will be of brass. The boilers will be ten in number, on the locomotive principle, to carry a working pressure of 120 lbs. on the square inch, having iron fire-boxes and brass tubes, with steel casing plates $\frac{5}{8}$ inch thick. The stays are all to be made of steel. All the steel used in the construction of the boilers will be supplied by the Landore Steel Company. The uptakes of the boilers will all lead into one chimney, which will be fixed. The boilers themselves will stand athwartships, and be divided into two groups of three, and two in each, with a fore and aft bulkhead running between them, thus making four stokeholes, which will be air tight; and when the engines are working at full speed the furnaces will be fed by air by a fan blast. It is anticipated that at lower speeds the air passing through the downcast shafts in the usual way may prove sufficient to supply the furnaces.

The total estimated weight of the machinery, including water in the boilers, is 490 tons, including the extra weight of spare gear, taken at 10 tons. At 490 tons the weight gives an average of only 1·782 cwts. per indicated horse power, and should the contemplated results be satisfactorily obtained, a great change in the type of machinery for future vessels in the Royal Navy would appear to be imminent.

In the summer of last year our attention was called to a steam launch belonging to the American Navy, and which had been brought to London by Colonel Mallory, of the United States Navy, fitted with a propeller capable of acting either as the steering or the propelling power, and possessing another great advantage, in that the main engines never required *reversing* for the vessel to go astern. I cannot do better than allude to the advantages claimed for this propeller.

A vessel can be moved ahead, astern, or sideways, or be turned in a circle the diameter of which does not exceed her own length, and otherwise manœuvred, with perfect ease and great rapidity by the helmsman without stopping or reversing the engines. She can, on approaching a quay, be moved sideways to and fro without first going astern or ahead, and can be steered with the same readiness in whichever direction she is moving, and for this no rudder is required, although it may be prudent to carry one on board to be shipped in case of accident to her machinery.

The engines always move in the same direction, and no reversing gear is required. The course of the ship is reversed by turning the propeller round its axis through half a circle, and the general handiness of the vessel's movements reduces very greatly the risk of collision.

The system had been successfully tried in America, and one vessel is stated to have steamed nearly 5,000 miles fitted on this system without a rudder, and the plan had been examined and reported on favourably by the engineers of the United States Navy.

Plate XXIII in this volume of the Journal[1] shows the position of the propeller and the machinery for driving it in a steam launch. The former is carried on a short horizontal shaft within the boss of the propeller, which is elongated for the purpose of receiving it, and to one end of which the blades are attached, and motion is conveyed to it by a pair of mitre wheels driven by a vertical shaft enclosed in a tube. To this shaft a small pair of horizontal engines are attached, which stand aft and occupy the space through which the ordinary tiller works; they are always working in the same direction *ahead.* The ordinary steering by the propeller is performed by hand, but steam power is in reserve when rapid manœuvring is required. And you will observe a pair of steering engines at the base of the column carrying the steering wheel capable of being rapidly thrown in and out of gear by means of a lever, so that the propeller itself can be rapidly revolved around its vertical axis from ahead to astern or *vice versâ,* or fixed temporarily at any required number of degrees in the entire circle, and whatever its position it always revolves around the same horizontal plane, whilst the vessel herself can be brought to a state of rest by the use of this motion. A tell tube or indicator is fitted, which communicates to the steersman the exact position of the propeller. The perfect command over the vessel possessed by the steersman was most clearly demonstrated, whether the launch was moving ahead, astern, or sideways, and she turned in a circle having her own length for its diameter.

The Admiralty has ordered a steam launch to be fitted on this system, and it may come into use for such purposes, but the great weight the system necessitates being placed in the extreme after part of the vessel will probably limit its introduction into torpedo vessels.

Credit for what they are doing in connection with steam navigation is deserved by very many whose names I have not brought under your notice; there is so much that is interesting going on at the present time, that I have found it impossible to condense within the limits of a paper (lengthy as this has been) all the information that I could have desired to lay before you. I have given you an outline of what is being carried out in our commercial marine fleet, and I have dwelt at some length on the different types of machinery recently constructed and being constructed for vessels of the Royal Navy. I feel our thanks are due to the Lords Commissioners of the Admiralty, Lloyd's Committee of British and Foreign Shipping, many of my own engineering friends, steamship owners and others, who so liberally responded to the request I made them, and enabled me to lay before you their present experience. I have attempted to do this in a form that I hope will prove satisfactory to the Council and Members of this Institution as also to them. My facts are authentic; and permit me, in conclusion, to express the hope, that whilst they may prove instructive at the present time, this record of them may conduce to future progress in Ocean Steam Navigation.

[1] See Mr. White's paper on "The Turning Powers of Ships," *ante*, page 557, *et seq.*—ED.

Appendix A.

No. 400.

Lloyd's Register of British
and Foreign Shipping,
2, *White Lion Court, Cornhill, London, E.C.,*
27*th April*, 1878.

Sir,

It has been brought to the notice of the Committee that in the case of some of the *steel* boilers now being constructed for vessels intended for classification in the Society's Register Book, the care necessary to be exercised in the working of this material has not been sufficiently recognised, and the plates have in consequence been greatly injured by the improper treatment to which they have been subjected, having in some instances cracked after they had been riveted up.

The Committee feel that it is of the utmost importance that the special qualities of the material should be duly appreciated by those engaged in the working of it, as the frequent occurrence of such unsatisfactory results, although due to improper manipulation, might tend to throw unjust suspicion upon steel for the purposes of marine boiler making.

I am therefore directed to request that you will bestow special care and attention upon the workmanship generally in the steel boilers building in your district. In addition to satisfying yourself that the requisite tests are satisfactorily carried out, you should take the necessary precautions to insure that all plates which are flanged or otherwise locally worked in the fire are subsequently annealed; and as there has been found to be considerable disparity in the shearing strength of the steel employed for rivets, this matter should likewise receive your careful attention.

In any case where there may be an absence of the needful care in the working of the material, you should draw attention of the Boilermaker to the fact, and if necessary report the circumstance to the Committee.

I am,
Your obedient Servant,
BERNARD WAYMOUTH,
Secretary.

Appendix B.

Lloyd's Register of British and Foreign Shipping.

Rules for Determining the Working Pressure in New Boilers.

Cylindrical Shells.—The strength of circular shells to be calculated from the actual strength of the longitudinal joint by the following formula:—

$$\frac{C \times T \times B}{D} = \text{working pressure.}$$

where C = constant as per following table.
T = thickness of plates in inches.
D = mean diameter of shell in inches.
B = percentage of strength of joint found as follows—the least percentage to be taken.

For plate at joint $B = \dfrac{p - d}{p} \times 100.$

For rivets at joint $B = \dfrac{n \times a}{p \times T} \times 100$ with punched holes.

$$B = \frac{n \times a}{p \times T} \times 90 \text{ with drilled holes.}$$

(In case of rivets being in double shear, $1{\cdot}75a$ is to be used instead of a)

where p = pitch of rivets.
d = diameter of rivets.
a = sectional area of rivets.
n = number of rows of rivets.

NOTE.—In Steel Boilers it is required that the strength of the rivets used to resist shearing should be shown to be at least 26 tons per square inch. If it is less than 26 tons per square inch, the rivet area should be proportionately increased.

TABLE OF CONSTANTS.

IRON BOILERS.

Description of Longitudinal Joint.	For Plates $\frac{1}{2}$ inch thick and under.	For Plates $\frac{3}{4}$ thick and above $\frac{1}{2}$ inch.	For Plates above $\frac{3}{4}$ inch thick.
Lap joint, punched holes	155	165	170
„ drilled holes	170	180	190
Double butt strap joint, punched holes..	170	180	190
„ „ drilled holes ..	180	190	200

STEEL BOILERS.

Description of Longitudinal Joint.	For Plates $\frac{3}{8}$ thick and under.	For Plates $\frac{9}{16}$ thick and above $\frac{3}{8}$.	For Plates $\frac{3}{4}$ thick and above $\frac{9}{16}$.	For Plates above $\frac{3}{4}$ thick.
Lap joints..	200	215	230	240
Double butt strap joints..	215	230	250	260

Note.—The inside butt strap to be at least $\frac{5}{8}$ the thickness of the plate.

NOTE.—For the shell plates of superheaters or steam chests exposed to the direct action of the flame, the constants should be $\frac{2}{3}$ of those given in the above tables.

Proper deductions are to be made for openings in shell.

All manholes in circular shells to be stiffened with compensating rings,

The shell plates under domes in boilers so fitted, to be stayed from the top of the dome or otherwise stiffened.

Stays.—The stays supporting the flat surfaces are not to be subjected to a greater strain than 6,000 lbs. per square inch of section if of iron, and 8,000 lbs. if of steel, calculated from the weakest part of the stay or fastening, and no steel stays are to be welded.

Flat Plates.—The strength of flat plates supported by stays to be taken from the following formula :—

$$\frac{C \times T^2}{P^2} = \text{working pressure in lbs. per square inch.}$$

where T = thickness of plate in sixteenths of an inch.
P = greatest pitch in inches.
C = 90 for plates $\frac{7}{16}$ thick and below fitted with screw stays with riveted heads.
C = 100 for plates above $\frac{7}{16}$ fitted with screw stays with riveted heads.
C = 110 for plates $\frac{7}{16}$ thick and under fitted with screw stays and nuts.

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Name of Vessel.	Description of Engines.	Diameters of Cylinders in Inches.		Number of Cylinders.	Proportion of Small to Large Cylinders.	Length of Stroke in Inches.	Number of Revolutions on Trial.	Indicated Horse-power on Trial.	Pressure per sq. in. on Boilers in Lbs.	Brass Tubes in Surface Condensers.			Diamet Shaft	
		Small.	Large.							Number.	Length.	Dia.	Crank.	Pro pelle
" Iris "	Twin screw, horizontal	In. 4 41	In. 4 75	Eight	3·3 to 1	36	97·18	7,713	65	Ford. 5,290 Aft. 7,024	Ft. In. 7 0 5 3	$\frac{5}{8}$ do. inside	$15\frac{1}{2}$	14
" Inflexible "	Twin screw, vertical	2 70	4 90	Six	ditto	48	73·26	8,909	61	13,300	6 0	$\frac{3}{4}$ outside	$17\frac{1}{2}$	16
" Nelson "	ditto	2 $63\frac{3}{16}$	2 $104\frac{1}{4}$	Four	3 to 1	42	79·05	6,246	60	9,940	6 2	do.	$16\frac{1}{2}$	15
" Northampton " ..	ditto	54 ins.		Three	—	39	85	6,000	60	10,000 square feet.			$14\frac{1}{2}$	13
" Shannon "	Single screw, horizontal	2 44	2 85	Four	3·73 to 1	48	65	3,542	70	6,746	7 2	$\frac{5}{8}$ inside	$17\frac{1}{2}$	16
" Comus " ...... " Champion " .... " Carysfort "	ditto	1 46	2 64	Three	3·87 to 1	33	96·38	2,406	60	2,200	6 2	$\frac{3}{4}$ outside	13	12
" Cleopatra " .... " Conquest " .... " Curaçoa "	ditto	2 36	2 64	Four	3·16 to 1	30	108	2,616	60	5,250 square feet.			13	12
" Polyphemus " as being executed	Twin screw, horizontal	4 38	4 64	Eight	2·83 to 1	39	100	5,500	120	10,600 square feet.			14	12[illegible]

	Diameters of Shafting.			Propellers.					Boilers.								Remarks.
											Tubes.			Furnaces.			
a.	Crank.	Propeller.	Stern.	No.	Description.	No. of Blades.	Diameter.	Mean Pitch.	No.	Description.	Number.	Length.	Diamtr. outside.	No.	Length.	Diamtr.	
b. - le	15½	14½	15½	2	Maudslay Griffiths	4	Ft. In. 16 3	Ft. In. 20 0	12	8 oval 4 circular	2,898	Ft. In. 6 5¼	In. 3¼	32	Ft. In. 7 0	Ft. In. 3 1½	Propeller shafting of Whitworth's fluid pressed steel.
t- le	17½	16	18	2	Griffiths	2	20 2½	23 0½	12	Oval	1,584 2,244	6 7½ 6 1½	3 3	28 8	6 7 6 7	3 6 3 3	ditto.
.	16½	15¼	17	2	Mangin	4	18 0	20 0	10	Circular	2,900	6 6	3	30	6 7	3 3	Hammered scrap iron.
	14½	13	15	2	Griffiths	2	18 0	19 0	10	ditto	2,950	6 6	3	30	7 1½	3 1	ditto.
n- le	17½	16	18	1	ditto	2	19 6	22 6	8	ditto	1,696	6 5	3	16	6 6	3 8	ditto.
t- le	13	12	13¼	1	Griffiths ditto feathering	2 ,, ,,	16 6	16 0	6	Circular	1,116	6 4¾	3	12	6 3	3 3	ditto.
	13	12	13¼	1	Griffiths	2	16 6	13 9	6	ditto	1,236	6 6	3	12	6 10	3 3	ditto.
	14	12¾	14½	2	Not yet determined on.				10	Locomotive	—	8 6	1⅞	20	6 0	—	Whitworth's fluid pressed steel.

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$C = 120$ for plates above $\frac{7}{16}$ fitted with screw stays and nuts.
$C = 140$ for plates fitted with stays with double nuts.
$C = 160$ for plates fitted with stays with double nuts, and washers at least $\frac{1}{2}$ thickness of plates and a diameter of $\frac{2}{5}$ of the pitch, riveted to the plates.

NOTE.—In the case of front plates of boilers in the steam space these numbers should be reduced 20 per cent., unless the plates are guarded from the direct action of the heat.

Girders.—The strength of girders supporting the tops of combustion chambers and other flat surface to be taken from the following formula:—

$$\frac{C \times d^2 \times T}{(L-P) \times D \times L} = \text{working pressure in lbs. per square inch.}$$

where L = length of girder.
P = pitch of stays.
D = distance apart of girders.
d = depth of girder at centre.
T = thickness of girder at centre. All these dimensions to be taken in inches.

$$C = \begin{cases} 6{,}000, \text{ if there is one stay to each girder.} \\ 9{,}000, \text{ if there are two or three stays to each girder.} \\ 10{,}200, \text{ if there are four stays to each girder.} \end{cases}$$

Collapsing of Circular Furnaces.—The strength of furnaces to resist collapsing to be calculated from the following formula:—

$$\frac{89{,}600 \times T^2}{L \times D} = \text{working pressure in lbs. per square inch.}$$

where 89,600 = constant.
T = thickness of plates in inches.
D = outside diameter of furnace in inches.
L = length of furnaces in feet. If rings are fitted, the length between rings to be taken.

The pressure in no case to exceed $\frac{8{,}000 \times T}{D}$

Donkey Boilers.—The iron used in the construction of the fire-boxes, uptakes, and water-tubes of donkey boilers shall be of good quality, and to the satisfaction of the Surveyors, who may in any cases where they deem it advisable apply the following tests:—

Thickness of Plates.	To bend cold through an angle of	
	With the Grain.	Across the Grain.
$\frac{5}{16}$	80°	45°
$\frac{6}{16}$	70°	35°
$\frac{7}{16}$	55°	25°
$\frac{8}{16}$	40°	20°

The material to stand bending *hot* to an angle of 90 degrees, over a radius of not less than $1\frac{1}{2}$ times the thickness of the plates.

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$C = 160$ for plates fitted with stays with double nuts, and washers at least $\frac{1}{2}$ thickness of plates and a diameter of $\frac{2}{5}$ of the pitch, riveted to the plates.

NOTE.—In the case of front plates of boilers in the steam space these numbers should be reduced 20 per cent., unless the plates are guarded from the direct action of the heat.

Girders.—The strength of girders supporting the tops of combustion chambers and other flat surface to be taken from the following formula:—

$$\frac{C \times d^2 \times T}{(L-P) \times D \times L} = \text{working pressure in lbs. per square inch.}$$

where L = length of girder.
P = pitch of stays.
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D = outside diameter of furnace in inches.
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Lloyd's Register of British and Foreign Shipping,
2, White Lion Court, Cornhill.

The CHAIRMAN: I am sure we have all listened with the greatest interest to the very remarkable collection of facts so lucidly and ably put before us by Mr. Ravenhill. I think all naval Officers will derive a certain amount of satisfaction from seeing how very admirably the Admiralty have kept pace, if not absolutely led the way, in all the modern improvements in steam engines, and that the reproach which has been sometimes cast upon their performances, that they were slow to adopt improvements, has no foundation in fact. Certainly not, in so far as regards these very various and very interesting new methods of applying steam to the propulsion of ships, which have been so well described by Mr. Ravenhill. The particular points which he has brought before us are the very great advantages of compound engines, and the extraordinary diminution in the consumption of coals that follows from their use; also the remarkable increase, which really almost passes one's belief, in the pressure now used on the safety valves of steam boilers. Instead of pressures of 5 lbs. per square inch, we hear from Mr. Ravenhill that an average of 80 lbs. is now obtained, and that they are going on to 90, and he mentioned some vessel which was working with something like 450 lbs. on the square inch. Of course these enormous pressures will require very great care, and I feel perfectly certain the naval Officers and engineers who are succeeding us will use with the greatest possible care, and with every appliance that science can bring to their aid, these most powerful inventions, and support the honour of the flag, and the bright and glorious name the British Navy has always held. I shall say no more upon the subject, except that one or two very ingenious things, so ingenious that one can hardly pass them by without a word of notice, have been brought before you. That system of the change valves, by which you change from a compound engine of high pressure to a low pressure, and an ordinary working engine, will be found, I am perfectly certain, a very great advantage, in many instances in which you have to go into action, and in which you would not like to use so high a pressure as 80 or 90 lbs.; consumption of coal I have adverted to; it is a most important consideration with ships so loaded with armour plating that any means should be taken by which we can lighten the load of other matters we have to carry. When we can spare hundreds of tons in our engines and coals we can apply some portion of that saving to the armament, both offensive and defensive, of our ships. Another very ingenious matter is the way in which the weights of heavy masses of cast iron may be greatly diminished by substituting steel. It is in the substitution of steel for iron that we shall find a remedy for the enormous weights our ships have now to carry, and which will enable them hereafter, without any increase of their dimensions, to support stronger armour, bigger guns, and greater speed. We shall be glad to hear any gentleman who feels disposed to enter into this discussion, and to ask any questions which may enable the lecturer to give such explanations as may seem requisite.

Commander CURTIS: I am sure all naval Officers must be very much indebted to Mr. Ravenhill for the way in which he has explained the compound engines, for it is to those and the use of high pressure steam that we owe the present economy of fuel. I should like to ask if combustion chambers could not be made under the boiler with return tubes through the steam. Mr. Thornycroft asked me if I could propose anything to prevent coals going up the chimney, and the foreman of one of Merryweather's engines told me he had frequently to cut coal out of the tubes. Professor Siemens utilizes all the gases he gets from coal, and if the coal was burnt downwards, if you had the ash-pit door double, also furnace door, syphons for air to pass up and through, and also the stoke door, the inner part perforated and shut, and had perforated air tubes or syphons going into the combustion chamber, you would allow the gases, after they have passed through the fire, to pass through the tubes, as carbonic acid and carburetted hydrogen, and go up through the under tubes and return tubes through the steam into the funnel. I have a specimen in my pocket of coal dust taken from the smoke box of a locomotive that had not been consumed at all in passing through the furnace or over it, and in locomotive engines in the course of a week there will be found 5 or 6 cwt. of unconsumed coal dust. Now I maintain it is perfectly possible to consume every atom of carbon by passing the gases of it through the incandescent fire, and not to pass carbonic oxide and coal dust up the funnel by putting on the exhaust. A Sheffield man told me that there are always two draughts in a chimney, an up draught and a down draught. I said,

"If that is the case, I would utilize the down draught to feed my fire." I took a sheet of iron, and closed from the lower bar to the hearthstone, previously having opened out a hole at the back of grate to communicate with chimney at back, and, to my surprise, the fire went down. I closed the register, and my fire burnt down so fiercely, that it actually melted the fire grate, quite a white glow of heat. I believe combustion chambers could be made to burn downwards so that you would have no smoke at all, except at first lighting, and consume all the carbon. Directly you put the coal on the fire it gets heated, and there are certain quantities of gases passing up the chimney not heated sufficiently to be burned, in fact, not in combination, "only mixed." If that gas passed through a fire it would be entirely burned in combination—either carbonic acid or carburetted hydrogen, and I think you might have heat accumulators of brick stacks in smoke box, somewhat in the way that Professor Siemens has in his mode of making steel on the hearth. By that means you will accumulate an immense quantity of heat.

NOTE.—By down draught combustion chambers, the water would be heated from the bottom of boiler, gases in proper quantities for combination, thereby obtaining heat sufficient to consume all the carbon and hydrogen, in fact, you will then obtain as nearly as possible to the chemical theoretical perfection, and not the prodigious waste that is going on now.

The present mode of supplying the air, I venture an opinion, is crude, as the air should be supplied equably to the fuel, and that is to be done by air syphons and natural gravitation. The air when heated will expand; it cannot return through the syphons, but must, by natural laws, pass through the minute interstices of fuel, having united with the gases of the fuel, and take its exit through the under tubes and return tube flues up the up tube and funnel.

Mr. J. F. FLANNERY: I should like to say how much some engineers, including myself, appreciate this paper of Mr. Ravenhill's, because he has collected some very valuable information. I would especially refer to the particulars of the Orient Line, which are very startling, very interesting, and very instructive. I should like to ask Mr. Ravenhill one or two questions on two or three points of detail, and first about Fox's corrugated furnace. Mr. Ravenhill gives us the particulars of two vessels, one of which had a grate surface of 294 square feet, and another had a grate surface of 260 square feet, the steam generative power of both being practically the same, and the speed of the two vessels equal. I should be glad if Mr. Ravenhill could add what is the coal burnt, and also state whether the conditions of stoking were nearly the same, because the difference between the grate area in the two cases does not seem to me to be sufficient to cause the experiment to be an entirely conclusive one as to the power of the Fox furnace as compared with the other.

The next point I have noted is with regard to the alteration in the factor of boiler shell, namely, when the shell is of great thickness, a certain amount of production of rust will reduce the strength in a different ratio of percentage in a thicker plate than in a thinner one. No doubt it is very desirable to introduce that difference in the form of a factor, but it seems very like too great a refinement unless in the case of very large boilers, and I very much doubt the applicability of a general rule producing such a factor. In the special case of steel boilers no doubt such a provision might be usefully made.

Mr. Ravenhill refers to the difficulty of keeping crank shafts from breaking, and states that Sir Joseph Whitworth is now directing his attention to building up crank shafts in different parts. I am not aware whether it is generally known that in that very engine of which you have a model before you—the White Star Line, that system is now being tried. I do not know whether the crank shafts are yet fitted, but they are made entirely in pieces, each piece is separate; that is rather an interesting fact, and I venture to mention it; we look for the result of that experiment also with much interest.

I should like also to refer to the model which is now upon the table—the Mallory propeller. I am quite willing to grant the whole of the advantages which are claimed to that system, which are, that it will quickly stop or leave a boat dead, reverse her, and enable her to steer extremely well; and the greatest difficulty, I apprehend, that has been experienced in torpedo boats, is to cause them to steer well. From the date of the first trial of the "Lightning," to the later improvements

which experience has introduced, the greatest difficulty has been found in getting torpedo boats to steer. That invention of Colonel Mallory will no doubt remove a great deal of that difficulty, but it induces another which Mr. Ravenhill indicated, namely, the altered and almost impracticable position of the propelling machinery. But there is still another difficulty which Mr. Ravenhill only hinted at. I do not know whether he intended to express it, that is, the use of a donkey engine for turning for steering purposes the frame carrying the revolving propeller. The action of the gearing pressing round the propeller itself in one direction—the power in a large torpedo boat being probably some 400 indicated horses—causes a tendency to turn the helm in one direction, and if it is desired to turn it in the other direction, you have to work against a large portion of the power of the main machinery working the gearing for propelling the ship; that seems to me to be a disadvantage, and to add to the gearing you must necessarily have for the driving power. To make this paper complete, Mr. Ravenhill might have added particulars of another invention which has been lately tried, and with the same objects; it is the invention of a Hungarian gentleman, named Kemstaten, and the particulars of it are something like these: Abaft the rudder or inside of it is carried a propeller, which is worked from the main shaft which is in the same horizontal portion as usual, by a universal joint, and that universal joint will give a moderately steady action to the steering propeller up to angles of 45° from the centre line of the ship; there are not in this arrangement the same features of objection which can be urged against the Mallory propeller, and the practical results are sufficiently important to warrant very careful attention to this invention. It has been tried on the Thames, and I have in my hand some particulars of the results. Mr. Ravenhill tells us a boat fitted with the Mallory propeller made a circle of 8.

Mr. Ravenhill: No, a torpedo vessel with two rudders.

Mr. Flannery: It was at all events a vessel which steered practically well, because it made the figure of 8 in front of the hospital.

Mr. Ravenhill: Going 15 knots.

Mr. Flannery: The "Hunstanton" made the figure of 8 inside the piers of Westminster Bridge. One of the gentlemen who was present is here, and could speak to that result if it were necessary. I think the whole circle was made in 58 seconds, and the boat was reversed in complete revolution in 58 seconds, and she went inside of one pier and outside the other with, I dare say, as great speed as could be shown by making the figure of 8 in front of the hospital.

The Chairman: Could you tell us the length of that boat?

Mr. Flannery: I think about 65 feet. I do not know whether it is given in the particulars of this pamphlet, but I shall be pleased to lay it on the table.

I can only say that this paper of Mr. Ravenhill's will take rank side by side with the former paper given by him before the Institution of Naval Architects as a reference for figures, and there is yet so much to be studied and recorded that I hope it will not be long before we have another such a one from him.

Admiral Sir Cooper Key: I would ask Mr. Ravenhill to be good enough to give us the results of these experiments on the corrosion of iron and steel plates; one can hardly tell it by inspection. I think they were tried under various circumstances—in warm water, cold water, air, and steam—and it would be very interesting to know what the result was.

Captain Scott: Mr. Ravenhill has spoken of the importance of the valves for altering the steam pressure from high to low. Would he likewise kindly tell us what time would be required to raise the steam from, say, 14 lbs. to 60 lbs. pressure on the square inch; for although it is very desirable to burn a small amount of coal by going at low speeds, it is more important still to be able to handle your ship quickly in action, and to charge with the utmost speed. I need scarcely say that most of those young Officers who are prepared to take part in future operations think that the ram is certainly the most formidable of the weapons that can be used at sea, and therefore I think the valve question as respects the time that would be taken in performing the operations needed, and raising the steam from a low to a high pressure, is a very important one.

Mr. Ravenhill: With reference to the observations that fell from Commander Curtis, I may say I do not think any one will argue that the boilers of the present

day are perfect boilers. Of course I feel diffidence in going into minutiæ on an occasion of this kind, when I really have been able to lay before you, through the kindness of friends, such valuable data as the Institution now possesses.

With reference to Mr. Flannery's remarks about Fox's corrugated furnace, he knows perfectly well the difficulty of getting at full detail. I should like to have been able to give this information a little more fully than I have done, but I was unable to do so. What I wished to convey was this—that the two steamers were of about the same tonnage dimensions, with speeds practically alike. I only know the name of one of them myself, and that I must not mention. In the one the boilers were fitted with eighteen plain furnaces, and had a grate surface of 294 square feet; in the other the boilers had twelve corrugated furnaces, and a grate surface of 260 square feet. The power the engines exerted was as nearly as possible the same. As regards the relative quality of the stokers employed, you must take, I suppose, an average. We know perfectly well that there are some firemen better than others, but in running over a series of time you may assume the firing in both ships would be very much alike. I do not know whether that meets what you wanted to get at?

Mr. Flannery: It is that the difference between the area of the fire-grate in the one case and in the other case is not sufficient to prove the advantage of Fox's corrugated tube as regards evaporation, unless it be stated at the same time what was the quality of the coal and the consumption.

Mr. Ravenhill: I do not attempt to put forward Fox's corrugated furnace as being superior. If you ask me the quality of the coal consumed, I tell you candidly I cannot tell you.

Mr. Flannery: It was necessary to make the information more complete, as it was a very interesting subject.

Mr. Ravenhill: That is right enough, but I say I have not got it. With reference to the Hungarian vessel you were speaking of, I did hear that there was such a vessel on the Thames, but beyond that I know nothing. I was induced to allude to Mallory's propeller because the Admiralty have thought right to try it in a steam launch. With reference to your remarks about the working of donkey engines and gear, I think, in speaking of the system as I did, I conveyed my own feelings when I said it may do for steam launches. I need not tell you that many years ago gear in connection with the screw propeller was altogether abandoned, I for one do not think for a moment the days will come when we shall ever see it in use again. I should be very glad if you would give me an opportunity of seeing the Hungarian ship you speak of, and witness trials such as you speak of, so that I could speak from my own knowledge. I am quite sure, if I may venture to say so on the part of this Institution, they would allow me to add the result of that trial to this paper.

Mr. Flannery: I think I may promise that you shall have the opportunity.[1]

Mr. Ravenhill: With reference to the remarks of Sir Astley Cooper Key, I may say the experiments I have alluded to are at the present moment being carried out, but it will be some time before Lloyd's Committee will be prepared to give any opinion upon the subject. Captain Scott put a question to me as to how long it would take to get up steam again after having used the change valves, say when steam had been reduced down to low pressure. If he had put it the other way I could have answered him from experiment. It is in a portion of my paper that I have had to omit, and which if you will allow me I will read:—"Before changing "the engines from compound to simple they must be stopped, and the boiler pres-"sure reduced from 60 lbs. on the square inch to 30 lbs., or any lower pressure de-"sired, and while this is being done the 'change valve' is moved as above described; "the time required to effect this was found to be in the case of the 'Comus' only "four minutes, so that the time from working compound to again working as simple "engines was not more than five minutes." I am not aware that any experiments have been made the other way, so much would depend on the state of the fires at

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[1] Up to the date of this Journal going to press, this opportunity had not been afforded me.—J. R. R.

the time; such a trial is generally made when the fires are dead and nearly burnt through, and there is no intention of getting steam up again. I am afraid I cannot give the time it would occupy except as a guess, and I would prefer not to guess.

The CHAIRMAN: There is nothing more to be done than to express the thanks of this meeting to Mr. Ravenhill for the most interesting and valuable collection of facts that he has put before us. This paper, in connection with that read at the Institution of Naval Architects, has contributed most important information with reference to the advancement of science in connection with steam machinery. Mr. Ravenhill is, as you well know, a practical man, who has in his day turned out engines that will compare with any. The kindness of those great and eminent manufacturers of engines who during part of his lifetime were his rivals in designing and constructing the splendid machines described to-day, and are now working cordially with him to give us, the British nation and Navy, the advantage of their immense practice and skill, has enabled him to come here and to give us a mass of valuable information and instruction, of which we cannot say too much. I think I know something myself of the trouble and difficulties that attend the collection of facts, for very often indeed, when I have tried to get at facts, I have found that they were, to use an expression which you may all have heard of, uncommonly slippery things, and that when you want to rectify by reference certain errors and mistakes which, with the best intentions, will creep into papers intended for use, you will find the difficulties of getting those errors and imperfections corrected are extremely great. I say that every one of us who has taken the trouble to master facts will be aware of the infinite trouble and labour that Mr. Ravenhill has taken in compiling this admirable paper. We should therefore, I think, facilitate his making this paper perfect in every possible way, and any attempt he may make to render it more complete will be received with thanks by the Council. I have only now to thank him most cordially in your name.

Evening Meeting.

Monday, March 31, 1879.

Lieut.-General C. P. B. WALKER, C.B., Member of Council, in the Chair.

ORDERS IN THE FIELD AND THE MEANS OF COMMUNICATING THEM.

By Major C. E. WEBBER, R.E.

It would be in the last degree presumptuous to attempt in half-an-hour to deal with a subject so vast, so full of interest to the Military Student, and so absolutely necessary to the Staff Officer, as that which is included in the title "Orders in the Field."

I shall only try to keep the minds of my hearers directed to those orders which may be called

Orders for Action,

which require the greatest amount of discretion in their preparation, and the results produced by which are of the last importance.

I will also ask you to divide my subject in your minds into the following:—

1. The resolution of the Commander.
2. The framing and drawing up of the initial order.
3. The further instructions necessary to carry out the order.
4. The means of communicating and delivering them accurately and rapidly.
5. Their reception and comprehension.

The reader will find plenty to interest him and instruct in such books as—"Correspondance de Napoleon I"; "Correspondence, &c., of "the late Duke of Wellington"; "Méthodes de Guerre," Colonel Pierron; "German Official Accounts of the Wars of 1866 and of

"1870–71"; which give thousands of extracts from orders; but the mass of them come under the head of proclamatory, instructional, and precautionary orders, and could not possibly be dealt with in one paper; indeed, the material at my disposal on the subject of "Orders "for Action," and the means of communicating them, is so ample, that I have had some difficulty in dealing with it.

When we contemplate how important it is that the wording of an order of any kind should be so clear that no mistake should arise in its execution, we cannot fail to realize the extreme importance of the art of framing orders when they are intended to guide military operations; and, allowing that the facility in doing so is an art which requires careful training and long practice, there will be little question that the time taken up in the consideration of the subject, as well as those matters which deal with the means of communicating orders in the field, will not be wasted to-night.

How many present can recall incidents in daily life when the careless use of language in conveying instructions to another person has resulted in disasters! There is not one of us who will not recollect an occasion when we have longed to revise instructions upon the accurate interpretation of which matters of great importance have depended, from feeling quite uncertain that the receiver has not grasped the order in its spirit as well as in the letter. Who is there that has not been in the position to accuse themselves of giving rambling instructions, too much in detail here, too imperfect there, unconnected and contradictory?

An order issued in the field should possess intention, scope, object, and first and foremost be based on a foundation of knowledge on the part of the *recipients* of every detail of the profession. Its intention should be unmistakable, the object to be attained clear, and its scope limited strictly to essentials. How vast has been the labour bestowed on the Army, which requires no more than a few sentences to set it in motion, and bring about great national results! Yet those few short sentences are composed of words, each of which should be weighed under the light of complete knowledge of every act which they will produce. The construction and precedence of each sentence may appear simple and easy, but the slightest change in them might dislocate an army and produce a defeat.

The machinist knows, that, once steam is turned on, every part of the beautiful mechanism he has executed will move in perfect unison, each following and fitting to each without a will of its own. The sower knows that his seed will grow into stalk and branches, leaves and fruit. But, the order which sets the vast machine of an army in motion has to contend with individual wills, misunderstandings, and idiosyncrasies, throughout its execution, and, however prepared the great machine may be, there are thousands of unforeseen contingencies that may arise in its mere interpretation and development which may mar the full result that the order is intended to produce.

Orders for Action are remarkably exemplified in the Official German account of the War in 1870. An order from a General Commanding-in-Chief to his army *may* be as concise as those of Count von

Moltke, and he *may* leave it to the lower commands to accompany the order with *instructions*. In these days of great armies, probably it is necessary to do so. But in no case *can* the accompanying *instructions* omit notice of some of the following matters, namely :—

The general position of the army.
That of the enemy.
The object to be gained.
The manœuvres preceding attack.
The positions of attack of Corps.
The positions of Reserves.
The support by one Corps of another.
The effects on movements of the Topography.
The strategical points to be held or won.
The movements of the cavalry, once the action of the other arms commences.
The weakness and the strength of the enemy.
Steps to be taken in the event of success or reverse.
The movements of the Head-quarters.

As a rule, such instructions are more " confidential " than the order itself.

It is a theoretical axiom of war that the Commander is the only source of orders, and that Officers of the Staff are the sole channel of transmission. However this may be carried out in practice, it must be absolute in the case of *orders for action*. But there should be no mistake as to what this means. A compiler of orders should never forget that, unless a service is to be carried out in an exceptional manner, there can be no greater folly or indiscretion than to include in the instructions anything descriptive of *how* the order is to be executed. Mischief has often been produced by this attempt to show that the writer has a little knowledge of *how* every one else's work is to be done. In the first place, no Commanding Officer likes, or should like, to be told *how* to carry out what he has been studying and practising half his life, and the Staff Officer who attempts such a thing is only bringing the good sense of his General into question. The employment of Staff Officers to supervise the execution of an order, so as to make sure that the measures adopted are best calculated to secure its fulfilment, has nothing to do with the meddlesome spirit which by interference with the Executive infuses a spirit of hesitation and know-nothingness into every rank.

One of the objects of the study of the Army, in time of peace, by Staff Officers is in order thoroughly to understand *how* the splendid organization of each arm possesses in its system an instinct of action, requiring in the field the merest indication, for it to carry out the *spirit* as well as the *letter*, of every *order ;* and to understand *how* to avoid dislocating that organization, by including too much detail in orders.

Although it has been attempted in time of peace, it will ever prove a source of failure in the field, the amalgamation of the duties of the Staff Officer and of the Commanding Officer. In such a position, an Officer never seems to know whether the orders he issues are his own or the Commander's.

Except on occasions for consultation, a Commander should not be accompanied by an Officer who is theoretically at the head of any of the Units, Arms, or Departments; the business of these Officers is executive, and their presence is required where work has to be done. If a General requires the presence of an Officer of each arm, and he would be unwise not to have a most experienced one, he should be on the Staff as a Staff Officer purely, and to help to draw up the *instructions* to accompany the orders for his own Arm. At the siege of Paris, for instance, when Generals Prince Hohenlöhe and von Kamecke, respectively Artillery and Engineers, were moved to Versailles from their commands, no orders for action, or instructions accompanying those orders, emanated from them, although they were stationed at the King's head-quarters. Every order passed through the usual channel, and Artillery and Engineers of each attack performed their share in carrying out these orders as part of the Corps employed on the duty.

Framing and Drawing up Orders.

General Lahure says:—"As every Staff Officer has to take his share "in writing orders, it would be absurd to expect uniformity of style." Each man has his own peculiar mode of expressing himself. The attempt to produce uniformity would only deprive the service of the special aptitude of each individual. One Officer has the gift which enables him to write a *proclamation*, another writes *reports* well, a third has concise and lucid ideas specially adapted for writing good *orders*, and a fourth is clever in writing a good *letter*.

Mons. de Bacourt tells of Talleyrand, that his system was to bring his modes of expression to bear on a paper already drawn up by his assistants. That Statesman had in reserve in his portfolio a number of notes and phrases bearing on almost every subject, and when a memorandum had to be drawn up, those applicable to the question under consideration were produced, handed to a Secretary with instructions how to use them, and afterwards the despatch was gone over and corrected by Mons. Talleyrand himself. As his view was, that a chief should never occupy himself in anything which his subordinate could do for him, he no doubt found this was the best way of giving a document all the necessary character of being the reflection of his own mind.

There is a good deal of evidence of the defective *wording* of reports and *orders* by men celebrated in military history.

This formed a subject of constant complaint with the great Napoleon. Writing to Marshal Lefebre from Osterode in March, 1807, he complains of "insufficient information." The same to his brother Jerome, whose reports he says were useless, "being without dates." The same complaint is made against Marmont, who has to be reminded that dates are of the "last importance." Prince Eugene, Viceroy of Italy, has to be reminded, that, "in reporting he should "acknowledge all the instructions received since his last." Writing from Liebstadt in February, 1807, Berthier is obliged to remind General Savary that "in reporting he should put himself in the Em- "peror's place, and consider what should be recalled of the subject,

"to the Emperor's mind," and "how far reference should be made to "what had gone before, so as to convey ideas as exactly and easily "as possible to the reader." Napoleon himself wrote thus, to Davoust —"Prince Poniatowsky (commander of the 5th corps), has a bad style "of writing, he is always grumbling, instead of writing facts. A good "description of the situation tells its own story, and can do no harm "to the General."

The Duke of Wellington, in 1811, had to issue a general order on the rough and offensive style of the written communications which were used in the Army. He also had, on one occasion, to rebuke the Spanish General, the Duc del Parque, for omitting every essential in a written communication, made to him by that Officer, on the subject of the passage of the Tagus by the Spanish Army, in 1810.

On the 6th August, 1870, at 10 o'clock at night, from St. Avold, Marshal Bazaine reports to the Emperor Napoleon III: "The last "news from General Frossard is that he is retiring 'sur les hauteurs' "without stating any direction."

The examples in negligence of style and expression might be indefinitely multiplied.

Wording of Orders.

Orders are executable, or badly executed, when clearness* is present with, or absent from, their preparation. An expression ought only to have one meaning. In a word, orders should be laconic, simple, and based on truth.

Precision of description and unmistakable expressions, are of the last importance in orders. Schellendorf recommends that such expressions as "in front," "in rear," "on this side," or "on that," of which the value is always relative, should never be used. It is much better, he says, always to describe positions by the points of the compass; but he abandons this in the description of rivers, when he prefers "right bank" and "left bank," "above" and "below."

Most of my hearers will recall the mistake made by the Corps under the command of General Soïmonoff, on the morning of Inkermann, which resulted in a failure in the development of the movement it was destined to carry out. It seems that the directing order was worded indicating the "left of the slope of the Kilen Balka ravine," when the left bank was meant. In consequence, the Corps ascended the right bank, which was on its left, and failed in its object.

Scope and Intention of Orders.

Napoleon the First wrote as follows:—"A Military Order requires "passive obedience, *only*, when it is given by a superior Officer, who, "being present at the moment he gives it, is acquainted with the situa- "tion of things, and can listen to the objections, and give explanations, "to the person whose duty it is to carry out the order." Wellington and the Archduke Charles have expressed themselves in the same way in almost identical language. The German General Staff seems to have

reached perfection in framing orders, which unmistakably convey that the opinion of its Chief coincides with that of his great predecessors.

On the other hand there have been many Generals who have ventured to believe that they could foresee all contingencies.

General Lauriston, in 1813, even went so far as to write "that it "never entered his head to serve his Emperor so badly as to leave "his subordinates without details explanatory of every possibility." He, I suppose, believed that he could be responsible for all, and that the best responsibility to be left to subordinates was to execute the orders they received. General Lopez attempted this kind of thing with the assistance of the telegraph, as I shall show further on.

The initiative spirit will never grow up in the minds of the subordinate chiefs if they are left without discretionary power in the exercise of their commands. If a General who consults his subordinates in the preparation of orders relative to administrative matters, is the one who always succeeds best in supplying the wants of those under his command, he will equally be followed by success if he follows the same course in the preparation of instructions to accompany orders for action, when such is possible. The greatest privation to which troops are subject will often be avoided by taking the opinion of Officers commanding regiments and battalions in such matters.

It is impossible to foresee or to calculate all the chances of war, and the only way to meet eventualities is to habituate subordinates to have no hesitation in acting according to the circumstances which present themselves. A subordinate who is tied by fixed rules, at the first critical moment may find himself plunged in difficulties, because events have proved different to what was anticipated when the orders were issued. He must then ask for further orders. The opportunity disappears and misfortune follows.

But such a consideration will not prevent Commanders-in-Chief issuing orders which will *guide* a subordinate how to act when in doubt. During the War of Secession, General Beauregard issued instructions on this subject to the following effect: "In consequence "of the difficulty of communicating orders in the country in which "we are operating, each Commander of a division, brigade, or regi- "ment will understand that, when he is without orders and finds him- "self embarrassed as to what he should do, he will move in the "direction in which the fire is heaviest." Beauregard explained the reason of this general order by saying that its execution would insure compliance with one military axiom, namely, the advantage of concentration for attack.

In the same manner, when the Crown Prince of Prussia crossed the French frontier in 1870, one important general order was issued to the 3rd Army, namely, "that if any advancing column encountered "the enemy the other columns within hearing were to move in the "direction whence the cannonade was heard, to join in the battle."

Grouchy, explaining his movements to Napoleon on the 19th June, 1815, accounts for his failure to join head-quarters with his army, by his desire to carry out an order he had received to attack Bulow, written at 1 A.M. on the 18th. On hearing the heavy cannonade

on the field of Waterloo, he seems to have taken it for granted that the Emperor was only engaged with the rear-guard of the English. Pressed by General Gerard to alter his movements, and turn in the direction where the heavy firing was heard, even when asked for permission to move towards the cannonade with the 4th Corps only, Grouchy still persisted in his move; excusing himself afterwards by saying that he did not consider himself authorized to modify his master's orders in this case more than on any previous occasion.

Disregard of Orders.

Sometimes we meet with instances of orders for action having been disregarded.

There is one curious instance during the Abyssinian Expedition most distinctly worded, and yet disregarded, whether deliberately or otherwise there is nothing to show. The order was drawn up on the 9th April, 1868, at the head-quarter camp at Dalanta Plain, about 12 miles in a straight line from Magdala. Between the Dalanta Plain and the group of precipitous mountains, one of which was Magdala, ran at right angles the Beshïlo River, 3,400 feet below; the road from Dalanta crossed the Beshilo and followed the Warki Waha Valley (called by Lord Napier in his despatch the Arogie Ravine) for about three miles. There it changed direction about 20 degrees to the right, and crossing the Dam Wanz Ravine rose about 700 feet to the gap between the Arogie and Afficho plateaux. Commanded on each side, it was obviously a hazardous route to which to commit the leading columns. The General's intention, expressed in orders, was that his leading brigade should avoid the Dam Wanz or Arogie Ravine, mount the Gumbaji Spur on the right (a climb of 2,000 feet), so as to guard the advance of the 2nd brigade by the ravine.

The order is as follows: "The 1st brigade, 1st division (with the "exception of the cavalry) under the command of Brigadier-General "Schneider, will take possession of the Gumbaji Spur, and encamp "there."

The brigade was composed of:—

A battery (Penn's) of mountain guns.
Naval Brigade with rockets.
Detachment Royal Engineers.
Madras and Bombay Sappers.
1st Battalion 4th K.O. Regiment.
23rd Punjaub Pioneers.
Wing 27th Beloochees.
Total, about 1,800 men.

The order distinctly laid down as follows:—

"The Naval Brigade with rockets, Artillery, and 4th Foot, will march "at daylight to the bottom of the Pass, with detachment of cavalry.

"The Sappers and Miners (350 men) will make a road leading from "the bed of the Beshilo on to the Gumbaji Spur, under the direction "of Captain Goodfellow, R.E."

The order went on to say that the infantry was to reconnoitre in advance of the sappers at work on the road, and when the road was practicable the guns and sailors were to follow. Evidently, when this was accomplished, the Brigade, following, would be secure on its right flank, while mounting the Warki Waha Ravine. But the first thing that happened was, that the infantry who were to cover the reconnaissance were too much blown to advance, and the sappers at work on the road were taken on towards the Aficho Plateau for that purpose. The road was therefore not made, and the guns and mules did not mount the Gumbaji Spur to accompany their brigade. On the contrary, the natural fortress of Falla, about two miles in front, showing no signs of life, the Officer conducting the reconnaissance, who must have been well forward, probably recollecting that no road had been made up Gumbaji, sent word to the guns and rockets to come up Warki Waha, believing that he could push on and secure the movement. This, as events proved, was only accomplished in time to save the guns from a critical position, as the general action with the Abyssinians, which commenced at 4 o'clock, closed the proceedings of the day. That the critical position of the mountain guns had the effect of drawing out Theodore's Army from its position on Falla, and thus leading it to destruction under the fire of breechloaders, is to the student no justification of what occurred. The Commander's resolution had been taken, that a road up to Gumbaji was necessary, the alternative road being in a deep ravine, and there can be no doubt that it was a wise one, and, so far as we can now judge, should have been carried out. But when failure does not follow, a disregard of orders is soon forgotten. We have heard much lately of an alleged instance of it, but as yet there is no accurate information on the subject, and it seems doubtful if there ever will be.

Orders consequent on Initiative Orders.

There is no doubt great difficulty, in excluding details from *orders for action* where general instructions *only* are necessary, and *only* enlarging on details when details are necessary.

A General Commanding an Army Corps, for instance, may give a distinct order to act with certain indications worded as follows:—

"5th————, 18——

"In accordance with army orders, the 3rd division "will occupy the "line ——————early on the 7th inst.

"The movement will be made so that the bridges at————and "———— will be free for the movements of the 2nd division by 11 A.M. "on the 6th. The 1st division will cross the————by the bridge at "———— ; after the passage of the————, the 3rd division will "then converge to the east and occupy the line———— ————.

"The enemy probably occupies—— ——and—— ——. As soon as "the 3rd division encounters the enemy it will manœuvre to turn his "right, and will not press any frontal attack, until the arrival of the "2nd division, which may be expected about————.

"Army corps head-quarters will be at———until 10 A.M. on the "6th, afterwards at——— "

How far the orders of the Divisional Generals will repeat the above, or be confined to the details of each line of march of each brigade and detachment, adding only such instructions as will ensure the correct movements, varies much in practice. Instructional and precautionary orders must arise out of and accompany the Head Quarter order, but much had better be left to them, if not to Brigadiers. This is obvious when one considers the number of details to be remembered, and the impossibility of the Superior Staff being able to deal with them all. For instance:—

The description of the composition of the columns and the names of the Commanders of each portion.

The routes, the communications, the objective of each.

The hours of departure, arrival, halts, &c.

The maintenance of the relative position of parallel columns.

The safety of the march.

The position of the various subordinate head-quarters on the march.

Arrangements for the crossing of lines of march.

Special instructions for the guidance of the transport, commissariat, and medical department.

Indications of procedure on encountering the enemy where he is expected, or unexpectedly; in the latter case, steps to be taken for concentration.

Orders for billeting and bivouacking.

Special detachments for special purposes, reconnaissances, and the conveyance of orders, &c., &c.

As portions of the initiative orders, so as to secure harmony of action, must be communicated to, and spread by the various subordinate chiefs, and, as brevity is the chief feature of a good order, it should be an axiom of the service (not to be laid down only at the commencement of a campaign), that the *manner* of execution *must* be freely left to the Executive.

The starting-point to enable us to come to a conclusion as to the way a service in time of peace should be ruled, so as to require no unusual instructions as to the meaning and scope of orders on taking the field, would seem to be, to assume:—

First: That, military training and organization means, that each individual in an army knows his position, his duties, and how to act on receipt of an order.

Second: That, theoretically, no positive order can safely be issued except directly by the voice of the person giving it, to the ear of those receiving it, and with reference to something that is within the range of the vision of the former.

Whether this unit is a battalion, half battalion, or a company, it is not desirable now to discuss. If these assumptions are allowed, it is evident, that orders from superiors must each be more and more subject to the conditions of manner and possibility of execution, the further the rank and position of each superior removes him from the recipients.

An interesting example of brevity in initiative is found in history, when Breda, garrisoned by about 7,000 Dutch, Flemings, English, and French, under a member of the House of Orange, was a thorn in the side of Philip IV. Spinola sent to the King a long report describing all the difficulties of the situation, to which he received the laconic order:—

"Marquis, take Breda,
Signed, "The King."

In consequence of this order, a siege was undertaken, and, after a brilliant defence, Breda fell.

It is the great misfortune of manœuvres that, with the intention of imparting instruction, Commanding Officers often deal with details, losing for themselves the exercise of watching a movement not executed exactly as they would have done it themselves; and, for the large number of men who naturally hesitate to act without precise instructions, the opportunity is also lost of learning how to carry out an order which is not minutely instructional.

Freedom of Action to Executive.

It must be indeed most difficult for a General in time of war thus to preserve the freedom of action of his subordinates, and, while not losing sight of the means at his disposal to gain his object, to leave to the chiefs of each fraction the independence necessary to the circumstances of their command.

Only think how much attention is involuntarily absorbed by the incidents going on immediately around one. For example: On an occasion it is told of a Corps General, who had placed himself near the flank of a battalion in one of his Brigades, waiting orders to attack. Suddenly a Staff Officer approached at full gallop and delivered the order from his Chief, that "General——— was to "attack." Oblivious of all the circumstances of his position, General ———turned, without hesitation, to the Officer Commanding the battalion nearest him, and directed him "to attack."

The temptation to a General to place himself where he believes his presence would produce an effect, must also be most powerful during the hours of a protracted engagement. And yet he must not yield. He must forget the fractions of his command in dwelling on the whole, and the object he has to achieve. At no moment must he more deny himself, any disposition to think of details, and this consideration must increase in importance, the higher is his Command. His is the rôle to "take resolutions," to give his whole mind to them, before and during action. He has no other duty.

All present recall the account of the battle of Busaco, and few will forget the general plan of the strong position held by the British on that day; but it is not generally known that the last order to the army issued by the Quartermaster-General at a quarter to five P.M. the evening before the action was as follows:—

"The camp-kettles and the meat are to be immediately sent for, and "the troops are to cook as soon as they arrive. Such regiments

"as can find means of doing so at hand may make huts. Picquets are "to be thrown out along the front and a connection to be established "between those of contiguous Divisions. A line of communication by "means of small posts is also to be established along the position "itself for the insuring the prompt circulation of *orders* during the night. "The General Officers commanding Divisions to be so good as to report "to the Quartermaster-General the place where each will be stationed "during the night. The whole of the troops to be under arms at "their respective stations on the position at half an hour before to-"morrow morning."

One can only read and wonder what the Staff of each of the five or six Divisions engaged could have been made of, to require instructions on three-fourths of the points referred to. Otherwise one cannot help admiring, in a certain way, the calm reticence of the order, on all the points upon which it comes essentially within the province of the Commander-in-Chief to give instructions.

The orders arising out of "resolutions" once given, must not have to be counter-ordered; considerable time is required to put in movement large masses of troops, and once in contact with the enemy it is generally too late to alter. "*Ordre, contre-ordre, désordre,*" is an old French proverb. *Necessary* and *unavoidable* fatigue in war is so serious that all *un*necessary expenditure of physical strength, which means waste of power, should be carefully avoided, and the troops themselves should feel conscious that when before the enemy the practice of manœuvres are being reversed, and that the exaction of extraordinary exertions, useful for hardening the soldier in time of peace, is abandoned, except when necessary for the conduct of the operations in hand. How much more is it necessary that all ranks should feel sure that no extra labour has been brought on them by faulty orders, either in peace manœuvres or in war. In the latter, "this assurance engenders confidence, during the former excessive "fatigue" (writes Schellendorf) "should be with a definite object." Troops, when kept on their legs for many hours longer than the ordinary average day's work, should be impressed with the fact that it is for some specific purpose.

The feeling that they are satisfying the call that is being made on them, together with care and precaution to provide their physical wants, is the best remedy for physical exhaustion.

It would be a vast mistake to ignore the existence of these feelings.

An instance of how they should be called on in plain simple language, and without exaggerated forms of expression, is given us by General Goeben, after the battle of St. Quentin, issued at midnight on the 20th January, 1871.

"The French army of the north is defeated. St. Quentin is "occupied by General von Barnekow and H.R.H. Prince Albrecht. "Two guns and more than 4,000 prisoners remain in our hands. I "congratulate the troops which I have the honour to command on their "victory. The next step is to make the most of that victory. To-day "we have fought, to-morrow we must march to complete the enemy's "defeat.

"He seems to have retreated partly on Cambrai, partly upon Guise, "we must overtake him before he reaches the line of his fortresses. "To do this, all troops will march to-morrow, not less than 22½ (English) "miles; whenever possible the infantry packs are to be carried in "carts.

"All the Divisions will start at 8.0 A.M."

The order goes on to describe the line of advance, but enough has been quoted for the purpose under consideration.

We find in this order, the General commanding an army, on the same night announcing to his troops the fact of victory with the proofs of it, they have done their duty, and he congratulates them. He then invites every mind to follow his own to the "next step" necessary, namely, to complete the defeat of the enemy, and the reason for the imminence of the necessity is described. The General announces the direction of the enemy's retreat, and enlists the anxiety of each individual to prevent him reaching a line of comparative safety; and yet he shows them that he has not forgotten that after all they are but human; no advance was to take place before 8 A.M. But *then* every man knows that he has got 22½ miles before him, and *may* even have to carry his pack through it all.

Resolutions having been taken, and orders issued, the Chief and his Staff can do little but guard that they have been communicated and understood, and watch the issue.

Communication of Orders.

Many hints have been given and rules laid down in connection with the *delivery* of orders in the field. As they are generally more or less influenced by the reports which are hourly ariving at Head Quarters, there can be no doubt that its position should be the best known spot in the whole field of operations, and when the General-in-Chief may be absent his *locum tenens* must be an Officer qualified to act for him. Orders should be sent hierarchically (quoting Pierron), but if urgency makes it desirable to shorten that route, too much importance cannot be attached to the necessity of duplicating by the ordinary channel. Napoleon writes, "occasionally by the omission of this, "Staff Officers do an immense amount of mischief." Marshal Victor complained of such a neglect on the part of the Emperor's Head Quarter Staff, writing from Vassy in 1814. An order had been sent direct to his cavalry, and in consequence, that destined by him for his advanced guard was absent.

Many arrangements have been made for the sure *transmission* and *delivery* of orders in the field.

Orders are verbal or written. Those for action are as often, in these days, the one as the other. But when they are verbal, they are generally so given in moments of the gravest importance. On such occasions it is preferable to confide them for conveyance to Officers of high character and great trustworthiness. As is well known, it has long been the custom to require the Officer carrying verbal orders, to repeat them to the Commander before he starts to convey them, and

on delivery it should also be the custom for the *recipient* to repeat the order aloud to the Officer who brings it.

Napoleon employed specially selected Officers to carry his orders. In action he frequently delivered them *vivâ voce*, and his Chief of the Staff gave the Officer the same order, written more in detail. In any case an Officer carrying a written order should be acquainted with its nature. If he has to pass through the enemy's country he ought to be accompanied by two picked cavalry soldiers. He should avoid villages and houses, follow a minor route, rest seldom, and then only in out-of-the-way places. He should move with one man a little way in front, the other in rear. At all times he should be ready to destroy his despatch, and be prepared with answers to questions in case he is captured. According to the importance, and every *order for action* must be important, these Officers, thus accompanied, should be employed to carry the order in *triplicate*, and they should proceed by different routes. Napoleon laid down that they should follow one another at half-hour intervals.

During the Franco-German war of 1870, the German Staff Officers thus employed, while within their own posts, carried a band on the arm to distinguish them. Thus marked, every one had to give way, and the Officer so employed had unlimited powers to take any means necessary to expedite the duty. The Russian Military Attaché, Baron Seddeler, specially remarked that, during that campaign, this service was remarkably well carried out, and with uncommon rapidity; and he pointed out that one cause was that every Staff Officer had three horses, and that the led horses were always kept within easy reach during action, and each Officer, on returning from such a duty, changed his horse. It is not a trifle to observe that Officers so employed should make it the rule to set their watches by that of the Chief of the Staff, so as to communicate with an order the hour of the watch by which it was timed.

Relays of Cavalry.

The establishment of Relays of Cavalry for the transport of written orders, is a subject which should be the study of every cavalry Officer, who, if instructed to make the arrangement, should endeavour to do so, so as to obtain the greatest expedition and security for the service to be carried out, and at the same time with considerable precautions as to the relief and protection of the men employed.

When General Fransecky, at Presbourg, in 1866, sent a brigade to take the Austrians in flank, he established a line of relays, consisting, at each post, of two Uhlans. It is told that several communications were sent from each end, but, as one post had been cut off by the Austrians, the chain was incomplete and therefore useless.

General Gourko's orders at Gorny Dubnick, October, 1877, give an example of the use of cavalry to form a more permanent chain of posts for the transmission of orders. The corps to furnish the posts are detailed: "From the 4th Cavalry Division five posts of five men "each between Frestennik and the village of Dolny Dubnick. The

"first post at the Head Quarters of the Corps and the last at Frestennik "at the Head Quarters of the Division. One of the intermediate posts "will be at Gorny Petropol, at the bivouack of the 3rd Grenadier "Division."

Again, "Along the line of intrenchments from the Head Quarters of "the Roumanians to the Head Quarters of the 3rd Guard Division, nine "posts will be established, the first post at the Head Quarters of the 3rd "Infantry Guard Division, the ninth at the Head Quarters of the "Roumanian position. The Kieff Hussars will furnish three posts, the "Mariopol Hussars three, and three by the Cossack Brigade. The posts "should be 400 paces in rear of the positions and one of them on the "high-road." Along these and the other lines established, Officers superintended. These Officers rode along the lines in their charge and inspected the posts, as they would have inspected those thrown out towards the enemy. One man at the post was to be always ready, and letters handed to the post by any Officer were to be transmitted.

One can well understand *how* such an important duty could be well or ill performed, and what precaution and forethought would have to be exercised by the Officer who superintended the arrangement. Indeed, I can well conceive that, without considerable practice, few Officers would be able to establish successfully such a line if it had to be of any length. I am not aware that such a problem as the following is put to our junior cavalry Officers in time of peace. Give a report and reconnaissance for a proposed line of posts for carrying despatches between————and————, add all particulars as to the instructions, numbers, means of relieving, speed of transmission, and steps to be taken by each post in case of emergency.

Field Order Books.

The various little books which have been prepared for the purpose of writing orders in the field, all sufficiently designate the necessity for enclosing, giving date and hour of being forwarded and received, and names of places, the value of receipts, and many other useful memoranda which have been issued from time to time by many Commanders.

Communicating by Telegraph.

The next stage in the means of communicating orders is by the Telegraph, either electric or by visual signals.

Its use in warfare is so well established that there cannot be two opinions as to its importance, and the intelligent use of it has now become a matter of military study.

Field Telegraphs.

Everything that can be said descriptive of the Field Telegraph Train of the various armies of Europe, necessary to be known by the military student, is to be found in print. From time to time minor matters of detail have been altered and revised, but these are of

little consequence to the General Officer, whose only consideration can be that his orders shall be conveyed promptly, accurately, and with certainty.

As I have said, a great deal has been written about Field Telegraphs, that is, the Telegraphs which have been arranged and specially adapted to meet certain conditions, which it has been considered all-important to meet, in using this means in the field.

The essential features of what is known as a Field Telegraph, are those which provide for its use under what may be called emergencies. In other respects it should not differ from any other Telegraph, indeed, in every such respect, it is a less serviceable Telegraph for general purposes, requiring special apparatus, and special arrangements, for its use, and in many systems it has come about, that the refinement in the adoption of specialities has militated against efficiency, and in the desire to render everything mechanically perfect, practical experience has been lost sight of.

A well-considered system of Field Telegraphs should be perfect in the simplicity of its appliances, and in the efficiency of its employés, because it is called on to do what is always the most difficult operation in Telegraphy, namely, to establish a communication rapidly with materials of not a permanent character, and maintain it with certainty.

There is a feature in Telegraphic Engineering which makes it differ from all other branches of science in which mind utilizes matter; and this is due to the subtle nature of the force employed, and to the difficulty, which any but very practically trained minds find, in quickly grasping every fact connected with it. For instance, the most perfectly devised Field Telegraph may be established and at work, and suddenly fail from one of many possible causes, and remain so for hours before it is restored. This is no reproach to the *personnel*, for, even in permanent Telegraphs, and with every possible precaution, such a thing occasionally happens, when a mind, which is not daily in the habit of meeting quickly these small difficulties, has to deal with such a case. In our Postal Telegraphs, everyone who has to do with the daily necessity which arises out of arranging for and working special communications established for Press and other purposes, is specially selected as the best of their class, to attend on, and supervise the operations; even then failures occur. How much more, when the effect of failure might be so much more disastrous, is it necessary to provide the very best devised means and the highest trained staff for the emergencies of war.

It has been sometimes said that Military Telegraphs are so simple that the efficiency of persons employed in State Telegraphs would be thrown away in attendance on them, because, to the outside observer, the latter *looks* so complicated with its number of wires and its intricate apparatus, while a mere line and an instrument at each end *looks* so simple. The reverse is the case. In State Telegraphs, with hundreds of wires and instruments everywhere, complete failure of communication need hardly ever occur, whereas, when all depends on one or two lines and few appliances, it requires very quick and ready resources indeed to foresee or prevent interruptions. It is not the complication

of many lines and instruments which it is difficult to grasp. It is the readiness of resources, the accuracy of investigation, and the prompt decision to act with certainty of success, which makes a practically trained Telegraph Engineer doubly useful in Military operations. Besides, the Military Telegraph Engineer may be called on at a moment's notice to adopt and use the existing State Telegraphs in his own or an enemy's country, and to do this a very thorough and varied experience is necessary.

The theoretical idea of a Field Telegraph at the front and an Etappen Telegraph in rear of an advanced central point is easy to write about, but very exceptional in reality. One wonders how any Military student, who takes examples of real military operations, and considers how a Telegraph could have been used in connection with them had it been known at the time, and, being aware of all the varied modes of such an application according to daily and hourly altering circumstances, could ever have laid down that Military Telegraphs should be divided in their working, material, and control.

The only exigency to guide the choice of a variety in Telegraph material for military purposes, is that which necessity and time prescribes. It should be as solid and secure as the time allowed for its erection will permit, and military wants may one day require a telegraph rapidly constructed, and as rapidly removed, on the flank or rear, as in the front. The heavier transport and material may as often be wanted close to the flank or front, as on the main line of communication.

He who would reproduce in the field the unfortunately unavoidable division of maintenance between the Railway and Post Office Engineer which exists in our State Telegraphs would only be courting inevitable failure in war. As a means of communicating an Order, would it be viewed with more favour by General Officers than now, if they knew that at one point the order was liable to more than usual risk of error by having to be handed over from one military system to another? With all its inherent liabilities to error, it would be a vast pity if our telegraphic means of *communicating orders* in the field were to be weighted with disadvantages arising out of the attempt to organize everything to one standard regardless of the laws of nature.

Again, we are sometimes told that *any* man, who can "*tap*, *tap*," as it is called, is good enough to forward or receive a message on a Military Telegraph line, and that the rapidity of what is called "commercial telegraphy" is quite thrown away for military purposes. A few hours spent in watching the work of a Telegraph Office would probably to a great extent modify these views, particularly if the individual had himself a smattering of "*tap*, *tapping*," and was to try a message or two. He would be very much like a European in the heart of China with a knowledge of the Manchourian alphabet, and nothing more. Experience has long proved, that to be accurate, which is the *sine quâ non* of Civil as well as Military Telegraphy, an operator must have learnt his business, as we learn a language. Eye, ear, and hand must have been in training from early years ever to become proficient at all. It is quite true that the wonderful speed

we hear of as being attained, is not of the same value as when time is money, but nevertheless, it is found that the qualifications which accompany great facility in that way are inseparable from efficiency in all respects.

Tapping Telegraphs.

We have been amused by the picture which has been seriously drawn, chiefly from anecdotes wafted across the Atlantic, of cavalry soldiers dashing up to a telegraph, placing an instrument in circuit, reading off all the secrets of the enemy, and, perchance, beguiling him to betray his own side by fictitious conversation.

To "come in circuit" on a telegraph wire is not in itself a difficult thing, and it has been done in America and elsewhere, and it would not be impossible under the circumstances described; and, there are trained telegraphists (carrying certain material and tools) who could do it, but, to "join in" on a working line and deceive the clerks at the distant stations, and successfully "tap" their news, would require talents, knowledge, and experience, only to be found in a few of the special servants of the Postal Telegraph service. That something of the kind has been done, there can be no doubt, but it has been done under circumstances totally different to those in which the "éclaireurs" of an Army usually find themselves.

Telephones.

From the great improvements lately made in communicating articulate speech, it will soon become a question whether for Military Telegraphs this means may not become more general. But the telephone has not yet reached a stage at which the present means can be permanently superseded. It would have also serious disadvantages. First, however efficient the apparatus, the person talking can be heard by those near him, and, without very special precautions being taken, every *order* communicated would be known to everyone in the neighbourhood of Head Quarters; second, *tapping a wire*, a difficult operation by a telegraph, is very easy with a telephone, and, while there would be no means of preventing a spy tapping every articulate communication, any attempt at deceiving could only be detected by recognising the accent of a stranger.

As very essential to the secure communication of orders, I trust the meeting will not object to my dwelling a little longer on this subject.

The Training of Military Telegraphers.

To meet the necessity of the British Army there have sprung up, under different auspices, three separate Institutions, for supplying trained military telegraphists, now classed as *line* and *office* telegraphers.

First, the Telegraph Field Train which is generally stationed at Aldershot. Second, the Telegraph School at the School of Military Engineering, Chatham, which has several commissioned and non-com-

missioned Instructors. Third, the Postal Telegraph Companies of the Royal Engineers, the 22nd and 34th employed in the Post Office and trained by its own Officers and non-commissioned officers employed in the maintenance and working of the Telegraphs of the South of England.

Time has brought about an "*approchement*" between these organizations, and no doubt will finally amalgamate them more or less. Between them, many Officers, and many hundreds of non-commissioned officers and sappers of the Royal Engineers have been well trained, and, between those actually serving and those in the Reserve, we shall, before long, have always ready a force amply strong enough to meet the largest demands which a war could make; and, if in future wars the Army reaps decided benefit from what has been done, much of its thanks will be due to several of our brother public servants in the Post Office Service for their co-operation. It is the only instance in this country in which a purely military organization undertakes the entire charge of a portion of a branch of a Civil Department, an application of Military labour in time of peace to a Civil work, perfectly legitimate, because it is the only means of practically training and maintaining in practice an efficient *personnel*, by the performance of work which, at least in the lower ranks, is more or less precisely what has to be repeated in the field.

I have only digressed to show, that in this country we shall be, even with our different system of Military Service, not a whit behind foreign countries in this means of *communicating orders*, and I myself believe, that as our Civil Telegraphs are well ahead of most others, it would be found, that the wholesome training in connection with them would place us equally in advance in the field.

By a decree of Marshal MacMahon, President of the Republic, dated 19th November, 1874, the rules now governing the French Military Telegraphs in peace and war were, once for all, comprehensively established; and it only requires similar rules to be laid down in this country, embracing all the existing means, and recognising the essential conditions of the services, Civil and Military, to produce equally well-understood and practical results.

The great difference between this country and those in which universal service exists, as it affects special services like the Telegraphs, is that, in the latter, the Military Telegraph Administration, in time of peace, simply organizes the *personnel* which is trained and kept in training in civil life, and the military cadres only are kept up. Each Military Region has its own Direction, and the men are recruited, first, from amongst the employés of the State telegraphs, who by their age are liable to military service, and secondly, from amongst volunteers under 40 who are above the age liable. But, with us, enlistment of *office* telegraphers must take place amongst the junior Postal or Railway Company telegraph *employés*, where manipulation has been learnt young, and the youth must then be trained as a soldier and afterwards put through a useful, technical training. Out-door or *line* telegraphers cannot be enlisted, they must be trained, *ab initio*, and their best qualifications are, having a trade, and being willing to learn. In

either case, each man, if he chooses to work, will have become so highly qualified in the occupation, in one branch or another, that in after life he can always command a market for his labour.

Employment of Telegraphs in the Field.

I need not remind my hearers that the Electric Telegraph has been used in the field, and so long ago as the siege of Olmutz in 1853. In the American War of Secession, upwards of 8,000 miles of telegraph wire was used for military purposes alone. During Sherman's celebrated march, his Head Quarters were generally in telegraphic communication with his base, daily, within two hours of halting. The success of its use in that war established it, to quote from Buchholtz, "as a burning military question."

The use of the telegraph as a reliable means of *communicating an order*, leads further to the inquiry as to how far it has been actually applied in late wars. There are several instances of its use on the battle-field, but there is *too* little record of the *actual* use made of it, or proof that it rendered service which could not have been performed as well in *any* other way. Foremost, we have the record of what occurred when it *was* established under fire on the field of Fredericksburg.

Lieut. Howgate, one of the United States Signal Officers reports, "at the battle of Fredericksburg (13th December, 1862), the field "telegraph lines of the United States Signal Service were first "worked under fire, although previously employed for communicating "between different portions of the Army."

"On this occasion it was extended from the Head Quarters of the "Commanding General to the right and left wings of the Army, and "when the advance was made another wire was carried with the "moving column, which was thus kept in constant communication "with the General Commanding and the other portions of the Army. "The operators were exposed to severe fire from the enemy at the "stations established on the north side of the Rappahannock, but held "their ground. Constant and reliable use was made of the line during "the battle."

Captain Buchholtz (to whose work, published in 1877, I have already referred) describes what would have been the advantages if telegraphs had been established from right to left at Solferino, and from front to rear on the morning of the battle of Wörth. In the one case the risks of the extension of the front of attack would have been lessened, and in the other the attack of the Bavarians and the 4th Corps would have been restrained.

American War of Secession.

The wide area of country operated over in America, North and South, has given us more practical examples of the use of Telegraphs during action than are to be met with in Europe.

During the American War of Secession, both sides used the Tele-

graph, the North to the largest extent. At first on the Northern side, the Military Telegraph Department, and the Signal Service Department, which included the Field Telegraph, were separate organizations "*running opposition to one another*" as they say, but the inconvenience of having different material and *personnel* became so great that in November, 1861, all the Military Telegraphs, of whatever description, were placed under General Anson Stager. The previous arrangement worked as badly as if the guns of a battery were in charge of the Artillery, and the waggons of the Transport. During the year ending 30th June, 1863, 5,326 miles of Military Telegraph line was in use, forwarding an average of 3,300 messages a-day. And in 1866 the mileage had risen to 8,253, with 81 miles of cable; besides which, nearly 5,000 miles of line belonging to the Southerners had been brought into use. The total cost of the Military Telegraph during the war was three and a-quarter million dollars. Mr. Plum, now an attorney at Chicago, then high up in the department, writes: "We had men drilled to erect field "lines, nearly as fast as a mule could travel with a reel of wire. Some-"times the wire was paid out from ambulances. We always main-"tained complete communication with all points during sieges, whether "besieging at Vicksburg, or besieged at Nashville. During an action "while investing Atlanta, I was at General Thomas' Head Quarters, "and received orders for him by telegraph for the movement of "troops. I have been frequently in actual telegraphic communication "with officers who were fighting to maintain a position. On one "occasion I was in General Rousseau's Head Quarters at Nashville "conversing on the wire with an operator who was in a stockade being "attacked by the rebels. They might have cut the wire, but for some "reason they did not. *Battle orders by telegraph became the usual means* "*of moving the troops, and that was the main object of our service.*" Again: "From beginning to end we employed more than 1,000 operators, "many of them serving through the whole war. Sound reading was "the rule. We always used cypher, even to the addresses. So "successful was the use of the telegraph for the conveyance of *orders* "to repel attacks, that the rebels became convinced that to attack "or even threaten either wing of the Federal Army was to arouse, "through the medium of the telegraph, the entire army." The conclusion drawn by most observers was, that in the Southern and Western districts the use of the telegraph was an essential element in the success of the war.

Paraguayan War.

I am indebted to my friend Mr. Treuenfeld, who was forcibly retained by General Lopez to direct the Military Telegraphs in Paraguay, during the war between that country and the Brazilians and their allies, for two very interesting cases evidencing the value of telegraphs in a war conducted through a wild and difficult country. They were used during the whole period between 1864 and 1869 by the Paraguayans, and 1867 to 1869 by the Allies. In December, 1868, the Allies were being held by the Paraguayans before the lines of

Angusturo and Loma. The right flank rested on the River Paraguay. Within the lines every point was joined by the telegraph with Head Quarters, and the Paraguayan leader had a telegraph line also to the capital, Assompcion, and was thus enabled to hold a very extended position with a comparatively small army. The river at Palmo, where the left of the Allies rested, was a kilomètre wide, and the other shore was an inpenetrable, wild, swampy country, called the Gran Chaco. The Allies, however, determined to throw a Division across, make a road through the Gran Chaco, recross the river about 20 kilomètres above, at Itororo, and take the Paraguayans in rear at Viletta. This they succeeded in doing, and telegraphic communication was at the same time kept up with the Head Quarters by a line some 23 kilomètres in length. Hardly had the division reached Itororo, when the river rose, and all communication, except by telegraph, was cut off. The Paraguayans made repeated attacks on the line, and the Allies used every effort to maintain it, and many lives were lost in the struggle. It remained in use until the 21st December, when the Paraguayans were driven by the flank movement from all their positions. Without the telegraph this would have been next to impossible.

Lopez was the autocrat as well as the General, and his theory was to direct everything himself by telegraph from his own Head Quarters, which were studiously kept beyond the zone of fire, within which he was never known to venture. At the battle of the Lines of Curupaiti on the 22nd September, 1866, the Paraguayan right resting on the river of the same name, the right and front was attacked by the allies with eight ironclads and a force of 14,000 infantry. The Paraguayans had 49 guns and 5,000 men engaged behind their defences, and the reserve was about 3 kilomètres in rear at Lopez's Head Quarters. General Diez commanded in front, and the loss in killed and wounded on both sides was over 9,000 men. One of the telegraph lines of the defence was carried a distance of $4\frac{1}{2}$ kilomètres from General Lopez's tent to General Diez at Passo Poqu, where there was a small earthwork behind which two operators worked a Morse inking telegraph, the wire being carried on palm-tree poles about 18 feet above the ground. During the whole action the Telegraph station was in the line of heaviest fire, one large shell burst in the parapet, half filled the work with earth, and upset the communication during 12 minutes, but the line was never broken, and only two insulators destroyed. While not receiving orders, General Diez was continually telling Lopez how the battle proceeded. Lopez sat in his tent listening to the operator interpreting the signals, and looking at the map. This was his invariable custom, and he was a man quite ready to have made his Telegraph Director responsible with his life for the lines being duly put up and maintained. He himself believed that this means enabled him to carry on a bloody and determined war for five years, until he had exhausted every man and every material resource in Paraguay.

The usefulness of the telegraph in the field will be most effectually reached by not attempting to do too much with it, by husbanding its

resources for the really important moments, and by applying it only where it can be made secure.

In the first place, there are two minds to be considered, namely, that of the General, and that of the Telegraph Direction. The General should be able to feel perfect confidence in whatever line of communication the Direction undertakes to establish; the latter, on the other hand, who alone can tell what his means at the moment will enable him to do, must never be constrained to attempt what his own experience tells him would be but an uncertain assistance. To put it in another way, cripple him with no administrative regulations, give him the material, men, and transport, and when he undertakes to establish secure telegraphic communication between two points, punish him if it fails. A good understanding would enable the Telegraph Engineer of an Army to make the telegraph of material service in many ways, not yet understood, and never to be understood, unless the individual who carries in his brain all the capabilities of his service can suggest as well as obey.

The *orders* conditional on eventualities, such as those to the Reserve, to the provision columns, to the great field hospitals, are those which a General is most anxious to have conveyed with expedition, when every man and horse is weary. Early information as to their position with relation to Head Quarters would give the telegraphs a large opening for usefulness to keep them busy during an action. The Officer in charge, and every telegrapher, would soon get to know that, to be successful, every energy must be directed to preparing for, and obtaining, eventual success, in conveying perhaps one or two messages in the day, or at most three or four. They would soon feel the enormous responsibility of making this transmission an absolute certainty. The Officer who wrote the message would in time learn that the wording of telegrams, so that no mistake can arise, and so that the message may not be delayed by superfluous matter, is the work of long practice.

And the message itself. What grand results, if a clear *order for action*, discreetly worded, can be quickly delivered to a distance; and what a miserable collapse if it fail.

Recollect the position of the Guard and reserve Artillery at Gravelotte, and say, was there not a moment on the afternoon of the 18th August, 1870, when a telegram from Head Quarters (if Head Quarters had been properly placed) to their position, might not have saved the battle, if even it had only been used to inform Marshal Bazaine that the road was blocked, and that any order to move would take two hours to carry out, instead of one.

It will be no less easy to see that, at times, suffering and waste of power could be enormously saved by telegraph communication with provision and baggage trains.

Take a peace manœuvre example. What was the cause of the slow marching, late arrival in camp, and still later watering and feeding of the troops in our Salisbury Manœuvres of 1872? Undeniably, the baggage and commissariat trains, composed of hundreds of carts and waggons, containing articles and food not required within five

miles of the front. The impression left on my mind at the time was, distinctly, that if the commissariat and heavy baggage vehicles had been camped three miles in rear, with a telegraph from the Head Quarters to the Transport Officer in charge, the Controller would have been less worked and better served; while the Army would have been saved much harassing and needless fatigue.

That the telegraph has rendered possible strategy which, without it, would be a grave violation of first principles, is remarkably illustrated by the last battle in Armenia, between the Russians under the Grand Duke Michael, and the Turks under Muktar Pasha. In October, 1877, the Russians decided to cut off Muktar's communications with Kars and Erzeroum, and thus, by threatening his front and rear, make his strong position untenable. General Lazareff was detached with this object, in command of 27 battalions, 40 guns, and 6 regiments of cavalry. Marching south, down the Arpa Tschar (River) he passed Muktar's right flank at Kotchiran, he turned to his right to Dighur, and thence making north-west, he made the Oghur Hill and the village of Vezinkoi, fortified by the Turks, his objective; and thus planted himself right on Muktar's communications. Now, what was it that made possible and rational this division of an Army in the presence of a powerful enemy? What prevented Muktar now crushing each portion in succession, as was evidently his intention, by his having immediately sent a large force, under Reshid Pasha, to attack Lazareff? It was, that along the 40 miles' march of that General, a reliable telegraph line had been constructed, which only once, and that but for two hours, was interrupted, and which, at 3 A.M. on the 14th of October, conveyed a message from Lazareff to the Grand Duke that Muktar was in front of him, with a stronger force than his own. Thus, as it were, placed face to face with his subordinate, 40 miles off, the Commander-in-Chief held his enemy in his hand. One small telegraph wire was round the neck of the Turk, and he could not escape. The combination was perfect, and the orders to attack on each side simultaneously carried out, with the result of the fall of Northern Armenia.

To divide an Army into two or more columns, in the face of a numerous enemy, without secure telegraphic communications between them, is simply to court defeat. And it is not to be forgotten that the taxpayer, who pays for war, has an interest in this matter. Each war that I have referred to has proved that the use of the telegraph saves men and material.

A light telegraph, carried on pack animals, and manned by highly trained soldiers, may, in the hands of a skilful General, be worth more than a strong brigade, yes, even than a division.

Such a telegraph is now in use by the Spaniards, whose experience has taught them that wheeled vehicles are not adapted to the work; and such ought, in my opinion, to be *the* telegraph of an army; able to move without occupying the roads, carrying a thoroughly reliable light pole line, constructed and worked by men highly trained in time of peace to foresee all the accidents to which telegraphs are liable. These men should be lightly weighted and

armed, and able to ride well enough to patrol their line on the pack animals.

And, above all, let these telegraphs gain such a reputation in time of peace, that Generals will as soon commence a campaign without *them* as without their *artillery*. They will then no longer be the subject of afterthought, but fill the *rôle* for which they are destined, the first in the field and the last out of it.

In concluding, I would beg all my hearers or readers, if they ever have the chance, to preserve for the instruction of students, *orders for action* and the *accompanying instructions* issued to any army to which they may belong, and at the same time to record all that comes under their observation, in connection with the *writing*, the *communicating*, and the *execution* thereof. A time will always arrive when these most instructive details can be made public; but, in the meantime they will bear in mind the following words of our Great Duke :—

"There is nothing more certain than that, of 100 documents, " 99 might be posted at the market cross, without injury to the public " interests ; but the misfortune is that, when the public business is the " subject of conversation, and is not kept secret as a matter of course " upon every occasion, it is very difficult to keep it secret upon *that* " occasion on which it is necessary. For this reason, secresy is always " best, and those who have been long trusted with the conduct of " public affairs are in the habit of never making public *any* business " of *any* description, that it is not necessary the public should know."

The d'Arlincourt Automatic Telegraph Apparatus.

There will be no attempt on my part to give a detailed technical description of these beautiful machines.

That before you is now receiving a facsimile of a message written this afternoon by the Quartermaster-General. That is to say, the writing on a piece of tinned paper is being reproduced on a piece of white paper at this instrument at the receiving station by my side.

Each instrument is provided with a drum for receiving and forwarding, the latter having a circumference $\frac{1}{300}$ less than the former, so that when a message has to be sent the other way, it is only necessary to change the drums at each station.

The process is a very simple one; at the forwarding station, the revolving drum, enveloped with the tinned paper, on which the message to be reproduced has been written with insulating ink, turns on its axis, and is touched in so turning by a little stile which travels slowly on a spiral slide lying parallel to the axis of the drum.

The battery there is connected with the stile, and the drum to the earth. A continuous current leaves the battery and travels to earth through the drum, the line of least resistance being by that route ; but, immediately the stile touches the insulating ink on the tin, the current passes to line, which is also connected to the stile, there being no other route open, and thus to earth at the distant station. On its way, it passes through the prepared white paper on the receiving drum, from the stile (which is always joined to the line) ; thus, the

current arrives at the stile which touches the paper with a minute steel point, and penetrating the paper, passes to earth by the drum. When no current arrives the paper is unchanged, but during the interval that a current arrives, owing (as I have said) to the insulation caused by the ink at the other station, so long is the chemically prepared paper discoloured and the facsimile of the ink-marks produced at this the receiving station.

The next point requiring explanation is that which relates to the synchronous movement of the two instruments, without which the reproduction would be inaccurate. What is wanted is that the drums shall pass under the two stiles exactly at the same rate; or, putting it in another way, that the stiles shall work precisely under the same conditions at each station. This is effected in the following way, and is one of the principal features of Mons. d'Arlincourt's apparatus.

First, he obtains mechanical synchronism of the clockwork at each station, by means of the diapason regulator you see on the top, and second, he obtains electro-mechanical synchronism, by means of a return current which the receiving instrument sends, momentarily, back to the forwarding station at each revolution of its drum. The evidence of it is seen by watching the little lever at the *left* of the instrument, which rises and falls each turn of the drum; and the work done by this return current is to start afresh the drum at the distant station, which, having finished its revolution before this one, has stopped mechanically and has to be started again by our current from this the receiving station.

The instrument is really very simple, although the mechanism looks extensive; the relay at the side is only used when the distance between the stations exceeds about 30 miles, and then, although special in its construction and essential to this apparatus, performs the same work as any other local relay.

So long as a current arrives of strength enough to overcome the electrical resistance of the paper, so long will the paper be marked in exact similitude to the ink-marks on the transmitting paper; there is thus considerable latitude permissible in the electrical state of lines.

Each apparatus (without the batteries) as you see it, case included, weighs 1 cwt.

The Cowper Autograph Telegraph.

Mr. Cowper has also been good enough to exhibit his beautiful apparatus here to-night; which, while not attempting the reproduction of facsimiles of ink-marks of all sorts, as in the d'Arlincourt, enables any one to write by telegraph at the rate of from 12 to 16 words a minute.

Mr. Cowper actually obtains from this little ink writing stile, a movement on *this* moving strip of paper, exactly similar to the movement of a pencil held vertically over a *similar* strip of moving paper and guided by the hand of the gentleman at the distant station.

You will see here that the little writing stile is moved by being drawn by fine cords, co-ordinately, in directions at right angles to one another.

These cords are moved by the (two) little metal plates which are carried within two pairs of coils of wire, precisely as the needle is carried between the coils of a galvanometer; through these coils a continuous current from a local battery passes, which keeps the needles in such a position that when the paper slip travels under the writing stile, a continuous black line is produced; but each of these pair of coils is under the influence of an electro magnet, the laminated cones of which you see protruding from the box underneath.

This influence, when active, immediately causes a movement of the small plates, which, tugging at the cords, move the inking stile in every direction over the moving paper.

This influence works by means of currents of varying strength by two wires arriving from the distant station, and it is by their strength that the movement is regulated.

How this is effected cannot be described accurately without longer time than we have at our disposal; but it is sufficient, to complete so superficial an explanation as I have offered you, to state that the varying intensity of the transmitted current is caused by slide contacts fixed at right angles to one another, and to the pencil guided by the hand of the sender. By means of these slide contacts, each position of the pencil transmits a current of a given intensity along each line of wire, and these intensities are so graduated that they produce to all intents and purposes similar movements in the pencil and stile at the stations.

Mr. Cowper: I have been asked to give a short explanation of my machine. The principle is this. In the first instance we have to decompose or resolve the writing into vertical motion and horizontal motion. If you will just consider for one moment, we can obtain any one position on the surface of the earth by latitude and longitude, and if we have the latitude and longitude given we know exactly where the point is, and if while a ship is passing over the ocean we continue it, and every minute take into account the two definitions, we follow the motion of the ship through the ocean. This instrument is so arranged as to take into account the absolute height and width of letters, and the motion in every moment, in each direction. It is impossible with electricity to send a curved indication, or knowledge of a curve, but it is possible to send knowledge of a certain line of vertical motion; it is possible also to send knowledge of horizontal motion, and this instrument exactly appreciates what the horizontal and the vertical motion is. This little pencil in the transmitting machine moves as we write, and it moves that rod in two directions. This end of the rod passes over a number of plates in this box, and as the little rod passes over the plates it gives a current stronger or weaker. We do not give dots or scratches or lines, and we do not in any way charge or discharge the wire; we never send alternate currents of negative and positive, but we always send one positive current at all times by each wire, one for vertical and one for horizontal motion. Those two currents vary in strength, and that is really the sum and substance of the mode in which this instrument works. We get constantly a gradually changed force, so that as the curves of the letter gradually change, so gradually the horizontal force and the vertical force also change. To electricians it will be of course obvious that those two currents varying would give varying forces at the other end. In the receiving machine there is a needle which moves in this direction at right angles to it. One magnet is attached to the wire, and as that force varies so the deflection of the needle varies, and, as the force of this other line varies, so does the deflection of the needle. And those two magnets moving alternately or together produce upon the one pen two motions, so that whatever motion I make with this pen at the

transmitting machine, that little pen at the receiving machine is doing exactly the same; that is to say, that pen absolutely obeys the motion of this pencil. That is really the whole and sole principle of the machine, and when I tell you the weight of the whole instrument does not exceed 50 lbs., that it requires only ordinary light wires, and can be moved about the field with the greatest possible facility, and gives written orders at the other end, you will see that it might in certain instances be of great utility. Of course with field telegraphs it is useless to talk about saving a man, although in commercial telegraphs it is an object to save one clerk out of two, because we require no receiving clerk to translate what is going through the instrument, but this writing absolutely records itself; and so for military purposes you would have the advantage of being able to write an order, at a distant station. A record is also kept of the message at the transmitting end. The writing at the receiving instrument is smaller than at the transmitter; we find it convenient to make it so, because written largely the letters are better formed, and therefore more legible, and the writing being smaller at the receiver is equally legible, and the message can be sent more rapidly by that means.

Mr. Preece: The subject that has been brought before the Institution to-night is one in which I have taken a great interest, and on which I have spoken in this theatre and also at Chatham. Of course in establishing any communication by means of telegraphy, there are three great points we have to ensure. The first is simplicity in construction and maintenance; the second, accuracy in despatch of messages; and the third, efficiency in the whole management of the concern. Major Webber to-night has brought forward two very beautiful and exquisite forms of telegraphy, in which one, perhaps two, but not all, of these requisites are obtained. I have always endeavoured to inculcate in those with whom I have been brought in contact, and especially the late lamented Colonel Home, that in securing simplicity, we ought to depend upon those instruments which appeal to us through the ear, rather than those which appeal to us through the eye, because in instruments that are worked by sound we have simplicity itself, and where we attempt to depart from this we introduce complication. Both the instruments you see before you are, in appearance, extremely complicated, but in reality, when you come to examine them, they are comparatively simple. But they are not so simple as the instrument known as the "simple sounder," the instrument which is best calculated to carry out simplicity itself. But we want accuracy, and there is no doubt that if you are able to transmit messages along the field, or between head-quarters and outlying divisions, such an instrument as that of d'Arlincourt's supplies the second requisite, viz., accuracy. That despatch is accuracy itself. I have myself, by means of that instrument, drawn a little sketch, and that sketch has been transmitted 240 miles, and it has there been reproduced with all my own inaccuracies upon it, the instrument reproducing even the shaking of the pencil and the rough dot, and whatever might appear in the drawing. Therefore you are able to reproduce with full exactitude words, plans, diagrams, portraits, or whatever may have to be sent. With this instrument of Mr. Cowper's you are able to produce the same thing, not by the exact reproduction of the writing itself, but by the reproduction of words, and in writing that can be distinguished between man and man. Therefore, by either of these instruments you undoubtedly do succeed in securing accuracy. But there is also with sound instruments, and even with other telegraph instruments, a means of securing accuracy, and that is repetition. Take, for instance, the control of trains on single lines. It is just as important that the order to the conductor of a train to move his train on in the face of a meeting train should be accurate as that the orders for the march of a division should be accurate. This accuracy in railway working is obtained by a species of double-entry. If an order is sent to the conductor of a train to send on his train to such a place, he has to send back an answer and say, "I will send on "that train," just slightly varying the phraseology, so that the manager of the line shall know with certainty that the orders have been received. The third requisite was that of efficiency, and I should conceive that whether the apparatus used be such as you have here, or whether it be the "simple sounder," indeed, whatever form of instrument be used, there is only one mode of securing efficiency, and that is by availing yourself of experience. We know that in a certain scientific branch of the service efficiency does exist, but still I doubt very much whether anybody here would

secure the services of a Royal Engineer to have his teeth extracted. It requires just as much experience to manage a telegraph as it does to extract a tooth, and it would be just as absurd to send a Royal Engineer to another part of the world to manage a telegraph who has had no experience in telegraphy, as it would be to send him to Chatham to extract all the teeth of the sappers there. Therefore, to us, who are acquainted with many Royal Engineers, who have been trained in our own nursery, who have been assisted to the best of our ability to acquire a knowledge of telegraphy, it has been a matter of surprise to find that the War Department in their arrangements have not availed themselves of the experience there obtained. When, for instance, an equipment was sent out to Cyprus, there was no officer from the Postal Telegraph Department selected, but somebody else. Now, a telegraph has been sent out to Natal, but no experienced officer from the Postal Telegraph Department has gone with it.[1] I say, that if all the requirements of a telegraph are to be obtained, they are only to be obtained by securing experience. If the right means are taken to secure the right men, I am certain that we can produce as much experience and knowledge in the management of military telegraphs as any nation in the world. I did feel somewhat surprised at an omission made by Major Webber, for in describing the different means of communication, he said nothing about visual telegraphy. Now I know that there is a system very largely used in India called Mance's heliograph, by means of which despatches are sent to great distances by flashing the rays of the sun, and in countries where the sun does shine—of course here, where the sun does not shine, such an instrument is not of much use—in countries where the sun does shine, such an apparatus is invaluable in the hands of military authorities. I see by the *Globe*, this evening, it is mentioned that communication has been obtained between Tugela and Ekowe by means of mirrors. Whether they have succeeded or not, the paper does not say, but at any rate a mirror, by flashing the rays of the sun or the rays of the lamp light, or by flashing other artificial means of illumination than the lamp, will certainly afford a means of communication between different parts of an army in the field, and where troops have been practised, as at the autumn manœuvres in 1872, in waving flags and flashing signals, and good results have come from that practice, it seems surprising that there are portions of the British Army in different parts of the Empire that are not properly supplied with these means of communication.[2]

Lieutenant-Colonel YONGE, R.A.: I think one great mistake made in starting the army system of visual signalling was the endeavouring to secure in the ordinary every-day soldier the same efficiency as is to be found in the practical telegraphist, or in the case of the instructed Royal Engineer. In using the electric telegraph the motion of the needle is to right and left, and that has been utilized in what is known as the Morse Alphabet, because I believe there is no other means of utilizing it except by compounding these two motions into a series of signs which become letters. In devising some simple method for use in the Army an endeavour has been made to find something to represent the needle; the flag therefore as a very simple apparatus, which is easily accessible, has been made to do the duty of a needle, and the soldier has been taught to wave this flag right and left, and so to make combinations, and form letters, which, it is hoped, instruction may enable him some day to go to the telegraph instrument and tap, tap the needle so as to transmit messages by wire. Now from all we have heard to-night,[3] it is evident that it requires long experience to work the

[1] Since this paper was read, Major Webber has been sent out to South Africa.—ED.

[2] It is now known that flashing signals were successfully made between Ekowe and the Tugela River.

[3] Mr. Preece has informed us that a sounding alphabet is not equally well adapted to usual signalling. The Morse alphabet was originally invented for use with a printing or "recording" instrument, to be deciphered at leisure; it was then adapted for use with "sounders," and the present generation of telegraphers, following the example of their predecessors, have adopted the Morse system for visual telegraphs, and one step further has sufficed to make it do duty with "flags." What was originally intended to leave a permanent record or paper, is now used for fleeting and purely transitory combinations, requiring the exercise both of good eyesight and good memory.

telegraph at all, and I think the hope that the average soldier could be put to a telegraph instrument to transmit a message will never be realized. It appears, as far as we can make out, that there has been no means of signalling between the force in Ekowe and those at the Tugela River. It would hardly be for want of apparatus, because those who have spoken and written in favour of what is commonly called "the flag system," say that no special apparatus is necessary; a stick or umbrella, or the waving of a hat has always been said to be quite sufficient. The distance, I believe, is considerable between Ekowe and Fort Tenedos, but still I believe from the latter post we have looked into Colonel Pearson's position. If there were any means of telegraphing at all, it would no doubt be seen by means of telescopes. Although in the matter of signalling it is supposed the Army is instructed so as at any moment to be able to use flags or any other apparatus, it would at any rate appear that within the fort at Ekowe there is no person who can make any sign. And as it contains a large portion of the naval brigade who themselves continually use flashing at night for signals, it is very curious that no communication has been maintained. The fact is, I think, it seems to be utterly impracticable to teach the average soldier the use of the dash and dot system. It is all very well while he is constantly practised at it, but in a short time he forgets it. Take the case of the Return recently published as to the efficiency in signalling of the Army at home. It commences with the C troop of the Royal Engineers, which is simply perfect; they can do anything they choose so try. But if you get down to the last regiment on the list you will find, while the speed is very much slower, something like $4\frac{1}{2}$ words a minute as against 11·36, the misses or false readings of letters were 50 per cent., 50 out of every hundred letters were illegible, and that was in connection with the slow signalling of their own regiment. Had the signallers been those of the Royal Engineers working rapidly, I have no hesitation in saying 70 or 80 per cent. would have been lost, and we all know the efficiency of a signal depends upon the accuracy with which it is delivered and received. In attempting the flag system of signalling, I think they attempt too much. If we could always have the Royal Engineers, and could always send skilled men with every column, it would be perfect, but in the absence of that, something simpler ought to be introduced. I take this opportunity of saying that such an apparatus has been introduced. I myself some years since proposed a simple means of signalling which has not met with any acceptance with the authorities in this country, but the moment that it appeared in print in the Proceedings of the Royal Artillery Institution, in the year 1872, it was taken up by the Austrian Staff. Exhaustive experiments were made, and the result was, their old "flag system" of signalling was entirely abolished, and my system is now in use in the Austrian army. It was employed in Bosnia. Some of the French and German periodicals give details of reconnaissances made and reported by signal from different points, while every detail of a battle was signalled to the Commander-in-Chief by detached Brigades, such as the approach of reinforcements, and the regulation of the artillery fire, and so on. Accounts given of my system in foreign periodicals, which are accessible to members of this Institution, show that the system in Austria has been found to work extremely successfully. Moreover, I undertake with this system to make any man a signaller in ten minutes, not only one man or six men per regiment, but as many as the voice can reach may be taught in twenty minutes.

This statement is no mere assertion on my part, but was actually proved to be fact during the manœuvres of 1874. When the Division of H.S.H. Prince Edward of Saxe Weimar was encamped at Frensham, detachments of four different regiments were placed at my disposal for experiment. In ten minutes they had mastered the whole system, and as the manipulation was purely mechanical and required no skill, one hour's practice sufficed to enable these detachments to signal for the Division during the engagement of the following day. This was in the month of July. A very favourable report was made to the War Office, but it was not until the following November, after great importunity, that I succeeded in obtaining an official trial. For this purpose I attended at Chatham, but owing to a dense fog this trial was unsuccessful. I do not pretend to be able to penetrate fog; but in like manner a telegraph wire is sometimes cut or damaged, and the heliograph requires sunshine. In short, no system is absolutely perfect under all conditions, but the

experience gained in Bosnia, where the signals have been clearly made out at distances of 10 to 12 miles, would appear to justify fair and exhaustive trials of the clock-vane system, as my system is called, and I am confident it would be found in every way superior to the present flag system, which evidently fails on an emergency.

Lieutenant G. M. BULLOCK, 11th Regiment: Perhaps I may be allowed to say a few words, having had some practice in signalling in my own regiment. I cannot help thinking the last speaker has mistaken the reason of the failure in signalling in the Army. It seems to me, from all the experience I have had, that the chief cause of failure is that sufficient interest has not been taken in it to work it thoroughly, and those who have been working it have not paid sufficient attention to its tactical use. Men are hurried through a course of signalling and passed as signallers, and at the time they pass, most of them can signal with very fair accuracy, and in a great many cases they keep up their accuracy afterwards by practice, but when they are employed in manœuvres or on field days they are never told what exact duty will be expected of them, and I really do not think many people have given much thought as to what exact use they are. They are sometimes considered to be buglers, sometimes orderlies, and are very seldom used in a way which shows their utility as signallers. I have always found whenever the stations of signallers have been moved about rapidly they lose communication, they get out of sight and are lost in clouds of dust or behind troops, or are shut out from view by hedges or other obstacles. But when in cases of defensive positions or reconnoitring we can arrange stations of signallers in front, we can keep up communications with great accuracy, though of course not with very great speed, because I do not think even with the best signallers you would keep up to eight or ten words a minute as the men are running about, and out of breath, but still you can get very fair rapidity and considerable accuracy. It is specially useful in any line of communications, as for instance in Africa. If one can judge from the pictures and maps we see of the country there must be a number of high points from which a regular net-work of communication could be established all over the country. It is most valuable for such purposes, especially in places where telegraphic lines might be cut or where there are broad rivers or inaccessible places to be passed.

Captain GROVER, R.E.: The penultimate speaker condemned the flag system in the Army, pointing out that Ekowe could not be communicated with from Fort Tenedos through our soldiers' ignorance of the flag-signalling system adopted in the Army. But it would be absolutely impossible to communicate by flag signalling between Fort Tenedos and Ekowe, because these points are about 25 miles apart as the crow flies. Without in the slightest degree wishing to depreciate the very valuable invention of Colonel Yonge, I submit that nothing can be urged against the system of flag signalling now in use in the army on account of the impossibility of communicating by its means between the Tugela and Colonel Pearson.

Lieutenant-Colonel YONGE: When I said the flag "*system*," I did not mean entirely flags. The apparatus supposed to form part of the equipment of the British Army includes the shutter, the heliostat, and the lime-light. They do appear to have had something like a mirror (which I suppose is the heliostat) in Ekowe, because one account says that they did succeed in making communication, and another account in the same paper says that they failed to do so. They had lights, I have no doubt, and might have communicated in that way, at any rate, had the system been in general use. Talking of signalling in India, I came across a paper written by Captain Wynne, 51st Regiment, and I have here his report, if you will allow me to read one paragraph. There were two columns moving from Peshawur and Kohat into the Jowaki Valley. The Peshawur column having started from Peshawur, where there was plenty of practice with the heliostat, had any amount of signallers, having obtained as volunteers the signallers of all regiments in garrison, but by-and-by one of the signal parties was told to look out for General Keyes' frontier force, which was expected every moment from Kohat The report says: "On the 1st of " January, we descried General Keyes' frontier force through our telescopes. They were " on the Dargai heights, but all our efforts to open communication with them failed, " probably owing to their having only one signaller, an Officer who was working with " heliographs of his own, and had very little assistance at hand. This was par- " ticularly unfortunate, as the interchange of visual signalling between the two

"columns would have been of great service." Now if there is no difficulty in instructing the soldier, why was there only one signaller in the Kohat column? I am sure it is owing to the difficulty in the dot and dash system that we have no efficient signallers, or no efficient signalling in the Army beyond the Royal Engineers, and even in the case of the Royal Engineers, visual signalling appears to be limited to nine men of the C Troop. (*Vide* Return annexed to G.O. 21 of 1879).

Captain WATKIN, R.A.: I should like to make one observation with regard to visual signalling. Two branches of Her Majesty's service, the Army and Navy, use a totally different system of flag signals. Surely one of these must be better than the other, and the inconvenience of having two systems precluding the services from communicating with one another must be obvious. It appears to me that the naval system is somewhat similar to the "Clock Vane" arrangements referred to by one speaker as being adopted by the Austrians. In the former, two flags held in different positions indicate the letters of the alphabet, and as far as I have been able to judge, this method appears more expeditious, less tiring to the eye, and causes less strain upon the nervous system. Take the letter B for example, in the Morse code, a dash and three dots, to represent which the flag has to be held down to one side, and then waved backwards and forwards three times—a difficult operation in windy weather, and the number of dots easily mistaken by the distant station; whereas by the Naval code the letter would be indicated by the flags held in a definite position, surely a quicker operation, and less fatiguing to read. The two systems could so easily be tried one against the other with little or no expense, that I should be glad to know whether any experiments of this nature have been made, to test their relative accuracy and simplicity.

Major WEBBER: I have very few words to say, as no one present has objected to anything I have put in my paper. I need only refer to what has been said in discussion since, and would like to bear witness to the great efficiency as signallers of the infantry and cavalry (and artillery too, although they are not so much engaged in signalling). There has never been found any difficulty in the soldiers learning the Morse alphabet or any other alphabet, in learning to be most excellent signallers, and becoming most intensely interested in the subject; but the difficulty lies in this, that every man who takes a great interest in such a subject in a regiment, is so useful for other purposes as a non-commissioned officer, and otherwise, that his services can never be made available in time of war for the duty of signalling, and that is the real difficulty why signalling does not prosper in time of war.

As regards moving stations, there is one remark I should like to make, which is, that it is one of the most difficult things for two moving stations to keep in communication. During the American War, although there was a great deal of signalling done by flashing, either with flags or lights, they found that it was no use in attempting it. Almost all the signalling stations were between fixed points. The difficulty principally lies in this, that it is a long time before one station is able to gain the attention of the other station. On the other hand, in telegraphy there is no difficulty, as long as the communication is uninterrupted, in easily gaining attention, because the receiver has only to watch his instrument; but, with the attention drawn away by so many moving instruments going on around, by the dust and smoke of action, and so forth, signalling as a rule is a means which cannot in any way be depended upon; that is to say, the difficulty does not lie so much in communicating when once you have gained attention, as in the act of gaining attention between one station and another. There is another point in which signalling in time of peace is never very practically tried, and that is, that it is generally used between points nearer to one another than would be thought of in time of war. Between such points, so near to one another as I have mentioned, a General would naturally employ mounted men. Signalling, to be of any great use in time of war, must be between points at such a distance that the legs of horses are really saved.

I do not know that the gentleman who spoke last has much reason in what he says, that there is less difficulty in learning the naval system of signalling than the present military system; but I would not deny the possibility of such being the case, and I should like to see such a competition as he described tried, under really practical circumstances, for it is a subject I have long taken great interest in, particularly if it was sure to end in a uniform system being adopted in both services.

The CHAIRMAN: Gentlemen, one advantage which we derive from the lectures in this Institution is quite outside the Institution itself. We not only hear, as we have heard to-night, a most admirable and instructive lecture from a member of our Institution, but we have the advantage of attracting to us gentlemen skilled in various branches of science, who are good enough to come here and assist at our lectures, and I think the first part of my closing words should be to call upon you to join me in thanking those gentlemen who have so admirably illustrated the subject that Major Webber has brought before us, and to Mr. Preece, who has on more than one occasion most kindly rendered the afternoon lectures instructive and interesting. I think we are indebted to my friend, Major Webber, for a very charming lecture. I promise myself great pleasure in reading it quietly and steadily, as well as in having heard it to-night. I will not say that I do not thoroughly appreciate the higher and scientific sides of the service to which I belonged for so many years; but there is a rougher side of it which is, after all, perhaps the most practical, and when one talks of orders in the field, one naturally turns to the subject of how orders are ordinarily conveyed, not when you have established an electric telegraph, not when you have established two lines of heliographs which communicate with each other, but when you are simply reduced to what every Officer ought to have in his pocket. And the first question almost that arose in my mind when I was put into my present post was, have we anything, in the shape of an ordinary field note-book, useful for the transcription of orders and for field sketching? I happened to go one day to Woolwich, and met that extremely able member of the Woolwich Academy, Lieutenant-Colonel Marsh, R.E., who showed me a capital sketch-book and order-book he had prepared. Going back to my office and talking over the incident with Lieutenant-Colonel Brackenbury, I found he and Marsh had been in connection, and happily were not working against one another. Whatever civilians may think on the subject, we do not always work against one another; we are very much in the habit of working with one another, army and navy, soldiers and sailors, together helping each other as much as possible, and Colonel Brackenbury and Colonel Marsh, without the slightest jealousy, were engaged in the laudable attempt of bringing out a note-book for the British Army, and I hope we shall eventually be able to lay this before the Officers of the service, not as a matter of order, but as affording them cheaply what is perhaps better than anything else that can be given. Captain Burgess has placed in my hands another, the invention of Captain Brooke, the Brigade-Major at Shorncliffe. I am always delighted when I find Officers really endeavouring to amend whatever is wanted to be amended in our service. This is his note-book, with means of writing and transmitting orders, also pencils, rule, &c., &c., contained in a leather pocket, which one can attach to one's saddle. It is admirably conceived, and most useful; but I know too well how one is reduced to the last ounce, and how difficult it is to carry anything so elaborate as this. The book which I hope eventually, by the assistance of Lieutenant-Colonels Brackenbury and Marsh, to offer to the service, is in three sizes, one for educational purposes, one for Officers of the Staff, and a smaller size, which every regimental Officer may carry in his pocket. The books are both note, memorandum and sketching books. They have paper ruled in squares to the scale of 100 yards to the side, that is four inches to the mile. By using the ordinary black interleaves, copies of either sketch or memorandum can always be retained.[1] Envelopes are carried in a pocket in the cover. They are marked with date, time, pace of orderly, &c. The only reason why this has not been completed is that the booksellers have been for six months endeavouring to obtain a watermark paper, the lines of which will stand in all climates. They have found that to be impossible, and we shall be reduced to the necessity of having the lines ruled in the usual light-blue colour, which after all, though it fails in a very bad climate, will stand long enough for all ordinary purposes. I am glad of the opportunity of this lecture to be able to mention that so much is being done in the mere ordinary way of writing and transmitting an order in the field. It is a subject on which a great deal might be said if there were more time, but I think I shall best meet your wishes, at this late hour of the evening, by asking you to allow me to return your thanks to Major Webber for his very instructive lecture.

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[1] Captain Brooke also has this arrangement.—ED.

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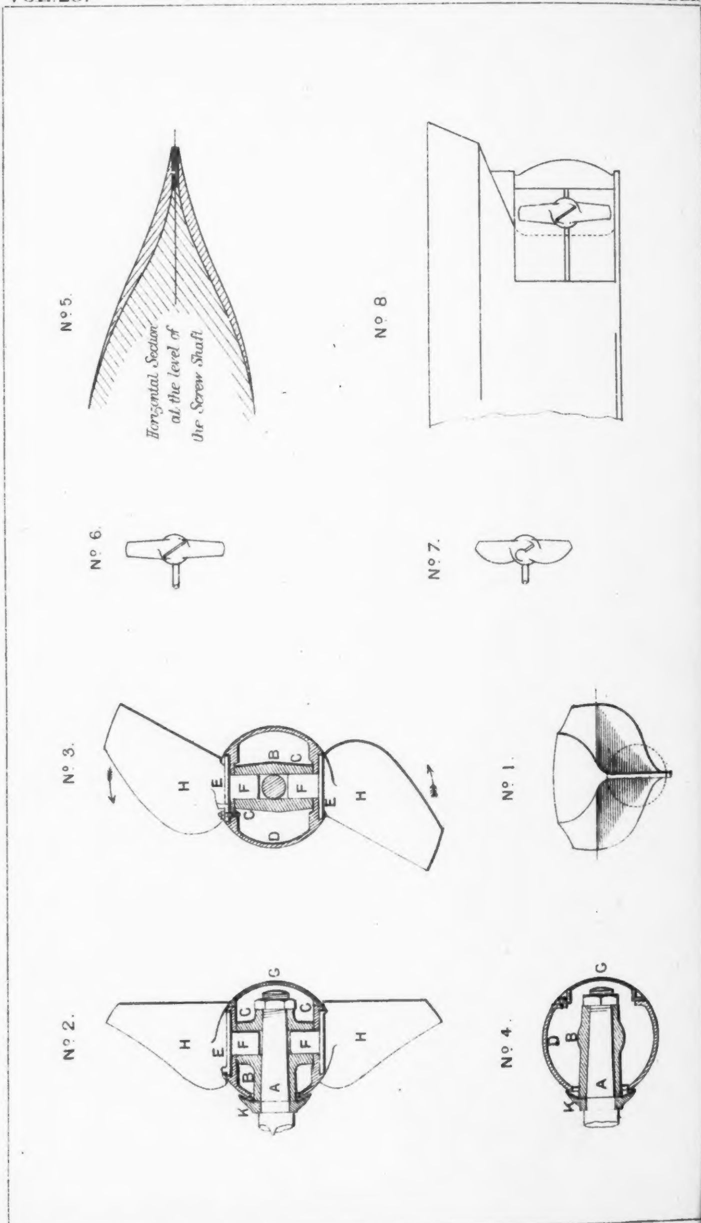

Nº 5.
Horizontal Section at the level of the Screw Shaft
Nº 8
Nº 6.
Nº 7.
Nº 3.
Nº 1.
Nº 2.
Nº 4.
A
B
C
D
E
F
G
H
K

J. Jobbin

Fig 11.

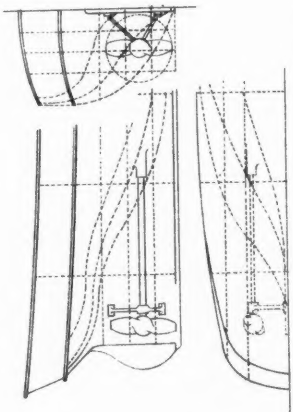


Fig. 12.

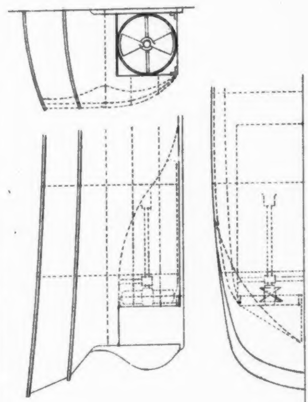


Fig 9.

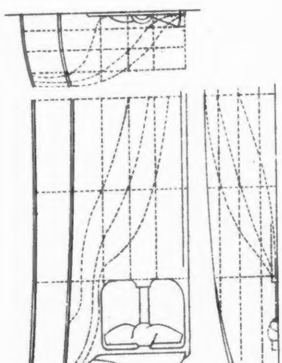
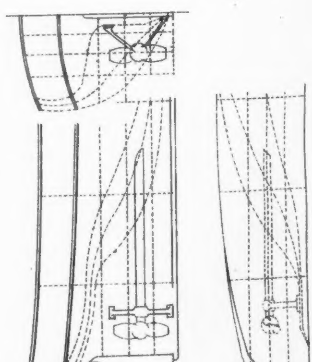


Fig 10.



J. Jobbins

Evening Meeting.

Monday, April 21, 1879.

Vice-Admiral E. GARDINER FISHBOURNE, C.B., Vice-President, in the Chair.

ON THE FORM OF THE STERN AND THE ARRANGEMENT OF THE PROPELLERS IN SCREW SHIPS, IN ORDER TO OBTAIN THE BEST EFFECT IN PROPULSION.

By Mr. Robert Griffiths, C.E.

In the paper which I have the honour to read this evening, my motive is to draw attention to a subject in connection with screw propulsion which appears to have been overlooked and neglected by engineers and shipbuilders, viz., the form of the stern in screw ships which will leave the water in the best state for supplying the propellers, and the position in which the propeller should be placed in order to avoid the suction of the dead-water, which is the principal cause of the increased resistance of the hull of screw ships. I am of opinion that this is the most important subject in connection with screw propulsion, being, if I may so term it, the very foundation on which the efficiency of the propeller depends. Since the introduction of the screw-propeller, the attention of engineers and shipbuilders has been chiefly taken up in improving the engines and the hulls of screw ships, and nearly all the improvements that have been made are due to the engineer, who has been able to obtain double the amount of power from the engines without increasing the consumption of coal; the shipbuilder also, by lengthening the hull in proportion to the beam, has increased the carrying capacity of screw ships, without reducing their speed, and by fining the bow and stern, has reduced the resistance of the hulls; but as far as their sea-going qualities are concerned, there does not appear to be any improvement, for the frigates and ships of war, prior to the introduction of the screw propeller, were as good sea-boats, if not better, than the modern built ships; and I feel convinced that the form of the stern, with the alteration shown in Diagram 9, would be best for screw propulsion, provided the screw be placed as far back from the wedge end of the hull as is required to give time for the water to flow in at the stern to balance the head resistance.

The screw has not been improved as a propeller since 1800, for the screw then invented and patented by Shorter will give nearly, if not quite, as good results, as far as speed is concerned, as any that has since been invented ; and all other qualities that are required are embodied in the screw I patented in 1849, and which has not yet been improved upon; in fact the screw as a propeller has not been understood. How often have statements been published of trials made with new and improved screws which gave greater speed than Griffiths' screws, but which have never been heard of since; and what is the practice now? Nineteen out of twenty ships are fitted with my propeller, the fact being that when a new screw is tried, it has either a different pitch, diameter, or position by which, in that particular case, some advantage in speed is obtained, and which is attributed to the propeller, until quite a different result is obtained with the next ship to which it is applied. It is now well known from trials which have been made, that a few strips of plate iron, secured to a boss on the screw shaft, and set at an angle which will hold the engines at the speed required, will give nearly as good results in speed as the best screw yet invented; it is therefore evident that we must look further than to alterations of the pitch, form, &c., of the screw, in order to improve upon the results which are at present obtained.

When making experiments in drawing water out of a model by the action of the screw, I discovered that there was considerable suction of the eddy-water, caused by the screw at the upper part of its disc. I had a telescopic pipe, $\frac{3}{4}$ inch in diameter, which led from a tank inside the model, and which could be pushed out till the end was close to the top part of the screw's disc. When this pipe was pushed out and was plugged at the inner end, the model went 48 feet in a minute, with 700 revolutions of the screw; again, when the plug was removed from the pipe, and the water was allowed to flow into the tank, and be drawn out by the suction of the screw, the model went 61 feet with 700 revolutions, while when the pipe was pushed in, the model went 75 feet with 745 revolutions. When the model was moored, the water would flow in through the pipe, and fill the tank in $10\frac{1}{2}$ seconds; if the screw was then started, it would empty the tank in 10 seconds, and when the model was going the screw would empty the tank in 8 seconds. These experiments were followed by others, by which I found that on the tapered part of the stern, near the screw, there was invariably a suction, which materially increased the resistance of the hull, and I concluded that instead of the taper of the stern coming close up to the screw, it ought to be finished some distance in front of it. In order to test this, I shortened the stern of the model and made the run as high up as the top of the screw, and $2\frac{1}{2}$ inches in front of where it originally ended; from the end of the run to the sternpost I had a parallel piece of the thickness of the sternpost, and the screw was left in the original position; this of course made the run or wedge-form of the stern fuller, as shown in Diagram 5. By this alteration the model gained 15 per cent. in speed, the power exerted being the same. I then altered the model to what it was before it was shortened, which reduced the speed to what it originally was.

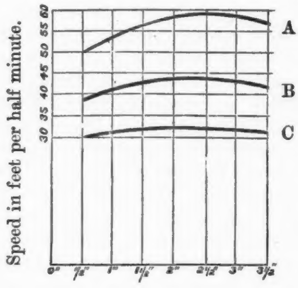
I have since made experiments with four-bladed screws, with blades the same width from the boss to the points (Diagram No. 6), and with blades tapered from the boss to the points on the leading edge only (Diagram No. 7), the result being that by lengthening or fining the run there was a slight increase of speed of 3 to 5 per cent.; but by shortening the run and making it fuller, and placing the screw about two-thirds its diameter behind the tapered part, and leaving the intermediate space open, or filling in a parallel piece of the thickness of the sternpost, an increase of speed of 10 to 15 per cent. was obtained, for which I account in the following manner. As the ship moves forward, the water closes in from each side of the stern to fill the space she occupied, and balance the head resistance; when the screw is in operation it sucks away the eddy-water at the top part of its disc, which mostly accumulates there, owing to the fulness of the run from the level of the screw shaft to the top of the screw, which water would follow the ship if the screw did not draw it away, by which the thrust given to the screw shaft is increased, and increases the resistance of the ship at least 40 or 50 per cent. more than it would have been, had the screw not been in operation. The only remedy that I have been able to discover, is to place the screw as far back from the tapered or wedge part of the stern as will allow the eddy-water to remain there, for which purpose the screw must be placed about two-thirds its diameter behind the forward sternpost, so that the stream line currents which flow on each side of the dead-wood will be drawn by the action of the screw, and meet in front of it, and supply it with water to act upon.

In order to obtain the full effect of the power that is exerted to propel the vessel, it will be necessary to form the sterns of screw ships as in Diagram No. 9 (unless shipbuilders can give a valid objection to it); the shortening of the dead-wood would reduce the displacement but little, and that could be compensated for by enlarging the counter above the screw, as shown, which would then take in its wake a portion of the water which the screw forces back. Modifications of the stern suitable for twin-screw are shown in Diagrams Nos. 10 and 11. In Diagram No. 10 the screws have a larger space than usual between them, which is obtained by reducing the diameter or placing the centric further apart, and the dead-wood is thickened and carried forward parallel until it reaches the tapered part of the hull. By this arrangement no tapered part of the run is near the screws, and the stern is materially strengthened. In Diagram No. 11 the taper of the run ends rather more than two-thirds the diameter of the screws in front of the sternpost, and thence to the sternpost, the dead-wood is parallel.

There is one other feature in connection with these experiments which proves the theory of my improvements. A piece of the dead-wood $1\frac{1}{2}$ inch long was removed, the screw being left in the usual position (Diagram No. 8); this made no difference in the speed, which was 51 feet in half a minute, with 525 revolutions per minute. The screw was then moved $\frac{1}{2}$ inch forward, and the speed was reduced to 46 feet with 525 revolutions; the screw was then moved another

½ inch forward, when the speed was further reduced to 40 feet with 520 revolutions; and, finally, when the screw was again moved ½ inch forward, the speed was only 26 feet with 500 revolutions. The piece of the dead-wood was then replaced, and the screw with leading part of the blades tapered off was tried ½ inch from the sternpost, and gave a speed of 54 feet with 545 revolutions; when tried 1 inch from the sternpost, the speed increased to 58 feet with 550 revolutions; at 1½ inch it was 59 feet with 550 revolutions, and at 2 inches from the sternpost 60 feet, with 555 revolutions.

Diagram No. 13.



Distance of middle of Screw from Sternpost.

Curve	A.	Full power................	560	revolutions.
„	B.	39 per cent. of full power ..	440	„
„	C.	17 „ „ ..	350	„

No. 14.

Angle of Incidence.			*Resistance at* 8 *knots.*
a	90°	......	32·93 lbs.
b	30°	......	31·89 „
c	19° 28′	......	10·44 „
d	14° 28′	......	4·51 „
e	6° 22′ 44″	......	0·00 „

There is very little doubt that in full stern and other ships the dead-water that is formed between the stern and the place where the outside streams meet, goes partly forward with the ship, and forms the wedge or taper-end to the dead-wood. This does not cause nearly as much resistance to sailing ships as it does to screw ships, through the action of the screw sucking it away. Colonel Beaufoy, by his experiments (upwards of half a century since), found that when the taper or wedge-

end of his model was at an angle of 6° 22′ 45″, there was no resistance at any speed up to 8 knots; but that when the angle was 19° 28′ 16″, the resistance at 8 knots was 34·34 lbs., and gradually increased from 0·2101 lb. at a speed of 1 foot per second to 34·34 lbs. at 13·527 feet per second, his model being 12 inches square with tapered wedge-ends (Diagram No. 14).

Screw propellers, when working, act on the currents of water which flow by the stern of the vessel, and by accelerating the velocity of those currents meet with the resistance by which they are enabled to push the ship forward. There is, however, considerable difference in the velocity at which the currents flow at different parts of the screw's disc, and consequently the screw's blades meet with more resistance in passing over some parts of the disc than others. This of course results in the screw giving greater thrust in some positions, as shown in the dynamometer diagrams of Her Majesty's ship "Rattler," in which the thrust varied between 2·9 and 4·1 turn in each revolution. Besides indirect proofs from thrust diagrams, direct proof of the difference of the velocities of the currents was obtained from experiments I was allowed to make with Her Majesty's steam pinnace No. 22 at Devonport in 1875, by measuring, with apparatus specially constructed for the purpose, the rate at which they flowed through the screw's disc while the boat was towed. These experiments showed that over the bottom-half of the screw's disc the water was little interfered with, and the water passed through the disc there at nearly the speed at which the boat was towed, but at the top-half of the disc the water was dragged with the boat to a certain extent, and only flowed through the disc at about half the speed at which the boat was going. Diagram No. 1 shows the results, the currents having the least velocity where the shading is greatest.

When a screw is working, the blades as they pass over the top part of the disc meet with more resistance than when they are passing over the bottom part, for as the screw, to obtain the thrust, drives back a column of water the size of the screw-disc at a velocity corresponding to the power employed, it has to accelerate the velocity more at the top of the disc than at the bottom, and consequently more power is expended on the top part of the disc than on the bottom, and from this cause the increase in the resistance of the ship (which Mr. Froude has proved is always from 40 to 50 per cent. of the total resistance of the ship), is considerably more than if the power were uniformly expended over the disc, for the ship is much retarded by the drawing away of the dead-water, so to speak, from the top of the disc, whereas accelerating the currents at the bottom of the disc would have hardly any effect on the ship. Again, as the blades one after another pass over the top part of the disc, and as at that place each blade meets with an increase of resistance, a series of jerks is given to the stern of the vessel, which is the cause of vibration.

Diagrams Nos. 2, 3, and 4 show a screw so constructed that the blades always meet with the same resistance. On the shaft A is fixed a casting B, with two sockets CC on opposite sides; the shell D of the boss, which can just pass over these sockets, has an elliptical hole

in the forward end, through which the end of the casting B passes, and which allows of a suitable amount of movement. The blades HH, which are formed so that most of their surface is aft of the middle of the boss, are constructed with flanges EE and shanks FF. These flanges are bolted in the usual way to the shell D of the boss, the shanks slipping into the sockets CC; a cap G completes the shell of the boss, and a cover K, fixed on the shaft in front of the boss, prevents floating substances entering the boss through the elliptical hole. It is obvious that as the blades have more than half their surfaces aft of the middle of the shanks, the pressure on their surfaces tends to fine the pitch; and also, since they are rigidly connected with the shell D of the boss, that as one blade turns, the other is also turned, the pitch of one being increased as that of the other decreases. When, therefore, one blade meets with more resistance than the other, the difference of pressure causes that blade to turn, reducing its pitch and increasing the pitch of the other until the pressure on each is equal. By these means the injurious action of the screw is, to a great extent, done away with. The cost of construction of this screw would not exceed that of an ordinary screw, and no alteration in the shaft or vessel would be necessary for applying it, and at any time the blades could be fixed, and the screw worked as an ordinary screw.

During the discussion of a paper on Screw Propulsion read at the meeting of the Institution of Naval Architects on the 3rd inst., Mr. H. Samuel Mackenzie stated that having seen in "Engineering" an account of some experiments with the screw moved close to the after sternpost, which I had made at the Royal Horticultural Gardens, he had the screw of his yacht moved back $9\frac{1}{2}$ inches, which was all his screw frame would allow, and by this the speed of his yacht increased from $9\frac{1}{2}$ to $10\frac{1}{2}$ knots; this corresponded with the extra speed gained by my model, but had there been room to move the screw about 24 inches (the screw being 5 feet diameter), he would have gained 2 knots at least. Another gentleman, Mr. T. Morrison Swan, informed me that, had there been time, he would have mentioned that a ship in which he was interested broke her screw-shaft abroad; another shaft shorter than the original one was fitted, and in consequence the screw was brought $4\frac{1}{2}$ inches nearer the forward end of the frame; this it was found caused a loss in speed of half a knot, but on the return of the vessel to England the shaft was lengthened the $4\frac{1}{2}$ inches, and the vessel returned to her original speed.

In conclusion, I beg to make a few remarks regarding the placing of the propeller as suggested. I find that it is the opinion of some people that my plans were invented and published by Mr. Froude some years since. There is no doubt that Mr. Froude proved by his model experiments that a saving of power would be effected by placing the screw one-third of the beam of the ship behind the stern, and also that the resistance of a ship is increased from 40 to 50 per cent. by the action of the screw; this he verified by his experiments on Her Majesty's ship "Greyhound;" he also stated, in a paper which he read at the Institution of Naval Architects in 1874, that 58 per cent. of the indicated horse-power is wasted in friction of the engines and

screw, and in the detrimental reaction of the propeller on the stream lines of the water closing in around the stern of the vessel. This I have no doubt is the case with screws placed near the forward end of the screw-frame at the termination of the wedge of the ship's stern, or with twin-screws when placed so that the points of the blades come close to the dead-wood; but if the screws are placed further off the dead-wood, and the stern of the ship is arranged as shown in Diagrams Nos. 9, 10, and 11, they have the contrary effect, for a screw in that case, being two-thirds its diameter behind the tapered end of the ship, draws the stream-lines towards it and feeds itself so that it leaves the eddy-water to follow the ship in the space between the screw and the wedge-end of the ship. With regard to placing the screw a distance behind the ship, Ericson patented the plan in 1836, and afterwards Beaty in 1850; it was also applied to the "Frankfort" merchant ship, and gave a very good result as far as speed was concerned, but the screw was moved to the ordinary position in front of the rudder in consequence of bad steering and the danger attending it in its unprotected position behind the rudder. It is a well-known fact to engineers and shipbuilders that there is no rule except the rule of thumb for placing the screw with regard to the lines of the ship and the power employed. This has been clearly shown by a ship recently built by the first engineers and builders of the day, for at the first trials a speed two knots short of that which was expected was realized, the two knots being afterwards got by only slight alteration in the screws, and no doubt most, if not all, of our naval and mercantile ships are from 10 to 20 per cent. short of the speed they would realize, if the screws were properly placed, or they might maintain their present speed with an equivalent saving of fuel.

The CHAIRMAN: I have long thought this a very important subject and one not sufficiently attended to; it is one which will afford very great results, at a very small cost for experiments.

Sir LEOPOLD MCCLINTOCK: I may mention that some 15 years ago I was able greatly to increase the speed of a steam launch, simply by reducing the length of the screw, and by removing it further from the foremost sternpost, in the mode which Mr. Griffiths has explained. I was not at the time at all aware of the scientific explanation which we have heard to-night, but there was the fact, that we greatly increased the speed of the boat by moving the screw a few inches further aft.

Commander CURTIS: With regard to the screw being astern of the vessel, a friend of mine had the "Pioneer," that went to the Crimea, a transport vessel, about 800 tons; her screw was 6 feet behind her rudder, and gave good results, but the objection was its overhanging, and being liable to foul. I think any one who was at the Society of Naval Architects the other day will perfectly understand the reason why the screw being placed so far away from the run of the ship gave improved results. Mr. Scott Russell fully explained the mode in which the vessel displaced the water, and the water following up the ship, maintains its own level or equilibrium, if I may so term it, due to gravity. Mr. Maginnies,[1] also, in his paper giving a description of screws, thoroughly confirmed Mr. Griffiths' principle, that reducing the diameter, and cutting away the corners or angles at the top and bottom of the screw, increased its distance from the run and counter of the ship, in

[1] In his prize essay on the screw, read at the meeting of naval architects, on 3rd April.

fact, prevented the screw from pumping the water away from the ship, or retarding its inflow. If you take an orange-pip and pinch it between your fingers, the orange-pip will slip out, and so the water acts upon the ship, after it has passed the extreme beam. After the water has been displaced forward, it must come in somewhere; it goes round behind, and forces the vessel ahead, and if you have the screw too near the ship, it pumps the water away from the ship in a measure, and retards it forcing the ship ahead. If the paddle-wheels are put close to a ship, they retard the action of the water closing in on it, and forcing it ahead. I understand there was a gentlemen who increased the speed of the steam fire-boat on the Thames from 6 to 7½ knots, by reducing the blades, and by placing them further away from the ship's side. But I think each ship will have its own peculiarity, that is to say, according to fineness of the lines and also the speed at which the screw will drive the ship. I was reading over the "Rattler's" and "Dwarf's" experiments in 1845, and these fully confirm the results of the smaller diameter screw, inasmuch as when they reduced the diameter and the length of the screw, they got better results. In fact, it appears the better pump the screw was, the worse it was for the vessel. Space should be left above to allow of the *natural* inflow, and the screw be sufficiently low down to admit of that; in fact, the screw below the keel gives excellent results.[1]

Mr. Griffiths: The old types of ships were very good forms for speed, &c. The "Royal Albert," built by Oliver Lang, bears out my statements *most fully*, the only alteration made in her was a false stern, not water-borne, to convert her to a screw. Here we have a 3,726-ton vessel, 500 horse-power, with a speed of 10 knots, not only on trial, but she did it a year after trial in calm weather; she was without exception in Lord Lyons' time the fastest vessel in the Mediterranean, as a rule, under canvas.

Sir Leopold McClintock: Would Mr. Griffiths give us a few words upon the skin-friction of the water as it follows the ship?

Mr. Griffiths: When I was at Plymouth I tried some experiments on a little launch there. By placing the apparatus (by which I measured the speed of the water) close to the side of the vessel, there was not nearly the resistance on it that there was on pushing it further off, showing that the water held to the side of the vessel. Many years ago I tried another curious experiment. I had a ball 3 inches in diameter, with a string to it. I went on board the old "James Watt," a paddle-ship on the Thames, and when she was starting at about 3 or 4 knots' speed, I dropped the ball in front of the rudder. It just twiddled quietly along two or three times, and then left the ship. But when the ship was going at 8 or 9 knots, the ball went right forward under the ship, and I had to hold it quite firmly, the suction was so great.

Commander Curtis: I have seen a bottle follow a ship a hundred miles in that way, dropped out of the gunwale port, close to the rudder of a ship.

Mr. Griffiths: It is astonishing the amount of suction there is at the stern of the ship, caused by the water flowing in to fill the space the ship has displaced.

Commander Curtis: A very curious thing once happened. A man fell overboard in front of a paddle-wheel, and we thought the paddle would have gone over him, but it beat the man quite clear. We tried afterwards with empty bottles that way. It appears the paddle strikes the water and sends a wave out. I should like to ask Mr. Griffiths what proportions he thinks best for men-of-war and merchant ships, having reference to the screw propeller.

Mr. Griffiths: The ships of olden times were of as good a form as any we could have provided; the propeller does not suck back the dead-water. They are the best sea boats, and I think would be the best ships. At the first introduction of the screw they thought a full stern was best, but they soon found out it was not. A small ship was fitted with a full stern; before this was done she went 9 knots,

[1] I state here on authority from a Staff Commander, who was on board one of the Indian troop ships, that by altering the pitch of the screw, the consumption of fuel was reduced from 80 to 50 tons, and the same speed was maintained. What does that mean? Either the lines of the vessel were faulty, or by inclining the shaft the screw had greater resistance to act against; *surely the cause is worth investigating.*—T. D. C.

and when they had finished she had dropped to 3. As they took off these liners her speed came back, and, consequently, ever since then the plan has been to lengthen the ships, and make them with very fine runs fore and aft.

The CHAIRMAN: Have you made any experiments with the screw below the bottom?

Mr. GRIFFITHS: None whatever. I have put the screws in tunnels, and they worked very well. There is a vessel now building at Glasgow on that plan.

The CHAIRMAN: How was the action of the screw when reversed?

Mr. GRIFFITHS: It would go astern just as well, and in the ship they are building now for the Greenwich Ferry there are two screws aft and two screws forward, and she will go each way the same. I made a model, and got nearly the same result with the forward screws as with the aft screws.

Commander CURTIS: Is the forward screw clear of the bilge of the ship? Because that is what I advocated here, that our large ships should have four screws and four rudders, and double-end rams.

Mr. GRIFFITHS: Yes; it is inside the ship. They would be the best ships for manœuvring; they would turn on their centres. I believe eventually that is what they will come to.

The CHAIRMAN: Would not it be a great protection from fouling to have the screw in a tunnel?

Mr. GRIFFITHS: Yes, in every case. They are now making some fishing boats on this plan to keep the screws clear of ropes, nets, &c., and the day will come when our men-of-war will have it. When we have lost three or four ironclads for want of protection to the screws we shall find the use of it, but it may be a good many years before people are convinced.

Commander CURTIS: By putting the screw in a tunnel you prevent it pumping back the water that acts on the ship. You feed the screw from underneath?

Mr. GRIFFITHS: All from underneath.

The CHAIRMAN: You can feather your screw so as to fill up the dead-wood?

Mr. GRIFFITHS: They might be made to feather, but there would be no advantage. Mr. Froude has proved in his experiments on the "Greyhound" that less resistance was offered to the ship when the screw was fixed vertically than when it was allowed to revolve.

The CHAIRMAN: Cannot you feather your screw?

Mr. GRIFFITHS: It is considered that there is no occasion to feather the screw with the narrow-pointed blades I use. That has been proved over and over again; they cause no resistance at all.

Sir LEOPOLD MCCLINTOCK: I commanded a ship with feathering screws. The feathering screw answered very well, and was a very convenient and useful thing. But there was a certain amount of machinery in the box, and you had occasionally to pull up your screw and clean it out. It would not do with a non-lifting screw for that reason.

The CHAIRMAN: Sir William Stewart told me the other day they had given up lifting; it was not worth the cost and space. They confine themselves entirely now to feathering screws.

Captain COLOMB: They do not even feather now; they just let them alone.

The CHAIRMAN: They fix the blade vertically.

Mr. GRIFFITHS: That is all, with two-bladed screws; with four-bladed screws there would be a drag no doubt.

Mr. BEGBIE: We are going to try Mr. Griffiths' plan on a couple of yachts. I have heard the statement from several of the most eminent ship-builders that there is nothing new in the idea. There are three vessels with screws abaft the sternpost I know of now, that have just been re-engined, that were built 14 years ago. I do not know of any myself having been built for the last 10 or 12 years. They were abandoned as causing far more trouble than gain; but we got a better speed out of them than with screws as ordinarily fitted. It is very difficult to get a vessel on which you can give an experiment like this a fair trial. As ships are generally built, we cannot throw the screw sufficiently far back to test it fairly; but as I stated, a couple of yachts will be tried next month. Mr. Mackenzie tried it on a 60-ton yacht, and he gained a full knot an hour by it. There is no question apparently but that some

very extraordinary results will be attained. Although people say there is nothing new in it, no person had the idea that such a small alteration as this could give such a large result.

The CHAIRMAN: It is just one of those things that proves that some of the smallest things produce the greatest results. It arises from this, that it is extremely difficult to get a fact. In this matter of the screws there have been a good many factors in the problem that have been wholly ignored, and the benefits of all are assumed to be the result of one changed factor when there were a great many changed. Nothing could be more loose or unsatisfactory, and yet a gain of 2 knots an hour on 16 represents a cost in coals as the cube of those numbers, *i.e.*, 4,095 to 5,832. See the enormous expense involved; and all that may be arrived at by a very small tentative process, inexpensive, followed out steadily, with only one changed factor. Mr. Scott Russell's idea of a full after body arose from the idea that the column of water is that which forces the water in behind the vessel; being at the surface, a shortened column, it cannot force the water in; and therefore you may have full lines of counter just as Mr. Griffiths proposes to compensate for finer lines below. But the finer lines below are just what you may have, because a high column of water would force the water in quite sufficiently to get the negative resistance you want. So that if you had been designing the best model for speed, quite apart from the screw, you would have got the best form of vessel to fix the screw to, that is, full lines above and finer as you get to the keel. I cannot help thinking it would be very desirable to have a kind of double or treble vessel where you would have two channels to convey the water solidly aft. The vessel would be equally good going stern or bow foremost. I believe myself the steerage would be vastly better. When your screw is pushed forward some distance before your sternpost, the water comes in and is a drag, and affects the ship very much; whereas, bringing the screw close against it, there is no water to come in, and the sternpost will not offer any resistance. I believe also the stream upon the rudder would be greater, and the vessel would steer better. I should like to ask Mr. Griffiths what experience he has had in that respect.

Mr. GRIFFITHS: In every case that I have seen, the closer the screw is to the rudder, the stronger is the water striking on that rudder, and the better the steerage. That is the failing of the screws placed behind the rudder, they will not steer. The force of the water is driven from the screw on to the rudder, and no doubt the nearer you can keep the screw to the rudder, the better the ship will steer. I am so confident as to this matter, that I have written a circular, which I shall send to shipbuilders, offering to fit these screws if they will give me half the cost of the extra engine power they would require to get the extra speed which my screw will give. They will then get the saving of the extra coal for ever.

The CHAIRMAN: I am sure it would pay the Government very well if they were to have experiments made and had ships that would enable them to do so. The expense would be very slight, simply the cost of the new propeller, and enormous economical results might be gained. I am sure you will allow me to return your thanks to Mr. Griffiths for his very interesting paper.

Report of trials made at the measured mile, at Gravesend, on the steam ship "Retriever," 80 nominal horse-power, 560 tons displacement, 174 feet long, and 24 feet beam :—

On the 8th July, with a four bladed Griffiths' ordinary screw, 10 feet 5 inches in diameter, 12 feet 6 inches pitch, in the middle of the screw frame, a mean speed of 10·89 knots with 89·7 revolutions of engines, 500·5 indicated horse-power was obtained.

On the 12th July, with the improved Griffiths' screw placed close to the rudder-post, a mean speed of 12·266 knots, with 80·8 revolutions of engines and 400 indicated horse-power was obtained.

NAMES OF MEMBERS who joined the Institution between the 1st April and the 30th June, 1879.

LIFE MEMBERS.

Primrose, Geo. A., Lieut. R.N.
Vander-Meulen, F. S., Captain R.N.
Leverson, G. F., Lieut. R.E.
Harpley, M. J., Vet. Surgeon Royal Horse Guards.
Adams, H. C., Captain 52nd Regiment.

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Hushe, E. V., Lieut. 41st Regiment.
Cooper, Richd., Captain 13th Regiment.
White, W. H., Esq., Assist. Constructor R.N.
Brooke, Lord, Captain Warwickshire Yeomanry.
Ellis, C. D. C., Major late 60th Rifles.
MacLeod, R. B., Major-General, Unattached.
Walsh, Edwd. C., Lieut. West Kent Militia.
Cary, B. P., Captain 35th Regiment.
Cawston, Rev. John, Chaplain R.N.
Sebright, Guy T. S., Lieut. Cold. Guards.
Taunton-Collins, H. E., Lieut. Somerset Militia.
Milner, F. H. W., Captain R.A.
Selwyn, C. W., Lieut. Rl. Horse Guards.
Anton, A. H. G., Lieut. 89th Regiment.
Sandys, T. Myles, Major 3rd Lanc. Militia, late Capt. 7th Fusiliers.
Taylor, G. L. Le M., Capt. 16th Regt.
Torrens, Alfred, Capt. late 66th Regt.
Campbell, Hon. A. F. H., Lieut. Scots Guards.
Richardson, J. M., Captain Northumberland Art. Mil.
Rice, H. C. P., Major 1st Sikh Infantry.
Davidson, G. F. de B., Captain 73rd Regiment.
Patey, Geo. W., Colonel late 56th Regt.
Porter, Basil, Dept. Commissary.
Watt, F. E., Com.-General.
Wainwright, Henry, Captain 5th Lanc. Rifle Volunteers.
Turner, John, C.B., Major-General R.A.
Loraine, F. E. B., Captain R.A.
Brooke, Arthur T., Captain R.N.
Annesley, A. Lyttelton, Colonel late 11th Hussars.
Wilkinson, Arthur, Captain 4th Regt.
Davies, J. G. S., Captain R.E.
Knowles, James, Lieut. R.N.
Grover, M. H. S., Lieut. 21st Madras Native Infantry.
Oliver, S. P., Captain late R.A.

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OCCASIONAL PAPERS AND NOTICES OF BOOKS.

This portion of the Number is reserved for Articles, either Original or Compiled, on Professional Subjects connected with Foreign Naval and Military matters; also for Notices of Professional Books, either Foreign or English.

It is requested that communications or books for review may be addressed, during the temporary absence of Lieut.-Colonel Lonsdale Hale, to

Colonel Sir LUMLEY GRAHAM, Bart.,
Royal United Service Institution,
Whitehall Yard, London, S.W.

"REVUE MILITAIRE DE L'ETRANGER."

The knowledge of the existence of this publication is confined to so few Officers in the English Service, that it is desirable to give to a notice of it the most prominent position in this portion of the Journal.

The *Revue* is a Government weekly military newspaper, edited in one of the bureaux of the French War Ministry, and circulated by the Government gratuitously, largely throughout the Army. The purpose of the *Revue* is to keep France posted in the latest improvements or alterations which may be carried out in foreign armies. Taking, for example, the thirteenth and fourteenth volumes issued during the two half-years of 1878, we find the following countries drawn upon:—Afghanistan, Alsace-Lorraine, England, Austria, Hungary, Bulgaria, Denmark, Germany, Spain, Greece, Holland, Italy, Japan, Roumania, Russia, Servia, Norway and Sweden, Switzerland, Turkey.

The subjects treated comprise—Administration, Small Arms, Small-Arm Practice, Military Art, Tactics, Artillery, Military Budgets, Camps of Assembly and of Exercise, Cavalry, Remounts, Railways, Staff, Study of Theatres of War, Fortification, Engineering, Military History, Infantry, Military Education, Maritime Affairs (to a slight extent), Medical Department, Mobilization, Organization, Recruiting, Statistics, Military Telegraphy, and Signalling.

In the articles which form the main portion of each number, criticism occupies a secondary position altogether. The chief object of the publication, namely, the dissemination of information, is steadily kept in

view. Sometimes, as in the case of tactics at the present time, when a controversy is being carried on, and discussions are taking place among Continental soldiers, the *Revue* performs the part of judge, so far as laying before its readers the most important arguments on either side of the dispute. As an instance of this, may be quoted the series of articles commenced in 1877, and not yet concluded, entitled "Les "Procédés Tactiques de la Guerre d'Orient." As a corollary to the original subject, the views held on the Continent with regard to the tactics of the future, and the bearing on them of intrenchments and long-range infantry fire, are now being placed before military men. In another branch of military science, viz., the training of the reserve forces, valuable information is afforded in connection with the German Landwehr. Another noticeable feature of the *Revue* are the "Nou-"velles Militaires," short paragraphs, frequently giving most valuable items of intelligence.

The *Revue* in some respects resembles the Journal, which, in our days, Albert Smith used to designate as the "Amiable Pirate," inasmuch as there is not a periodical of any value in Europe which, through translations or otherwise, is not drawn on for information.

It seems extraordinary that a work of such value should have in our Army so limited a circulation; because to us, left behind as we have been during the last half-century in much that appertains to army organization and field work, it is a matter of the greatest importance to learn exactly what is being done in other armies, and to have before us the standard of improvement which the most advanced have reached, and to which our own Army can easily attain if only the nation give the word.

Napoleon, in his description of the qualifications of a General, included a knowledge of foreign military matters. The same knowledge would appear to be necessary also to the Staff who may have to assist the Generals in carrying on operations. But regimental Officers would equally profit by perusing the *Revue*. The cavalry Officer, thirsting for information as to the higher leading of his arm, and finding English literature somewhat deficient in this branch of our profession, will in the pages of the *Revue* find accounts of the methods recommended abroad, and moreover the sources whence he can obtain further particulars. Artillery, Engineers, and Infantry will, each and all, find articles treating of their branches of the Service.

It is not too much to say, that any one who steadily digests this weekly budget of foreign military information will be kept perfectly *au courant* to everything of importance which is taking place in the countries with which it deals. The subscription, post free, is only 16 francs. The *Revue* can be obtained either through any English bookseller, or direct from Paris. The name and address of the administrateur is A. de Forges, 152, Rue Montmartre.

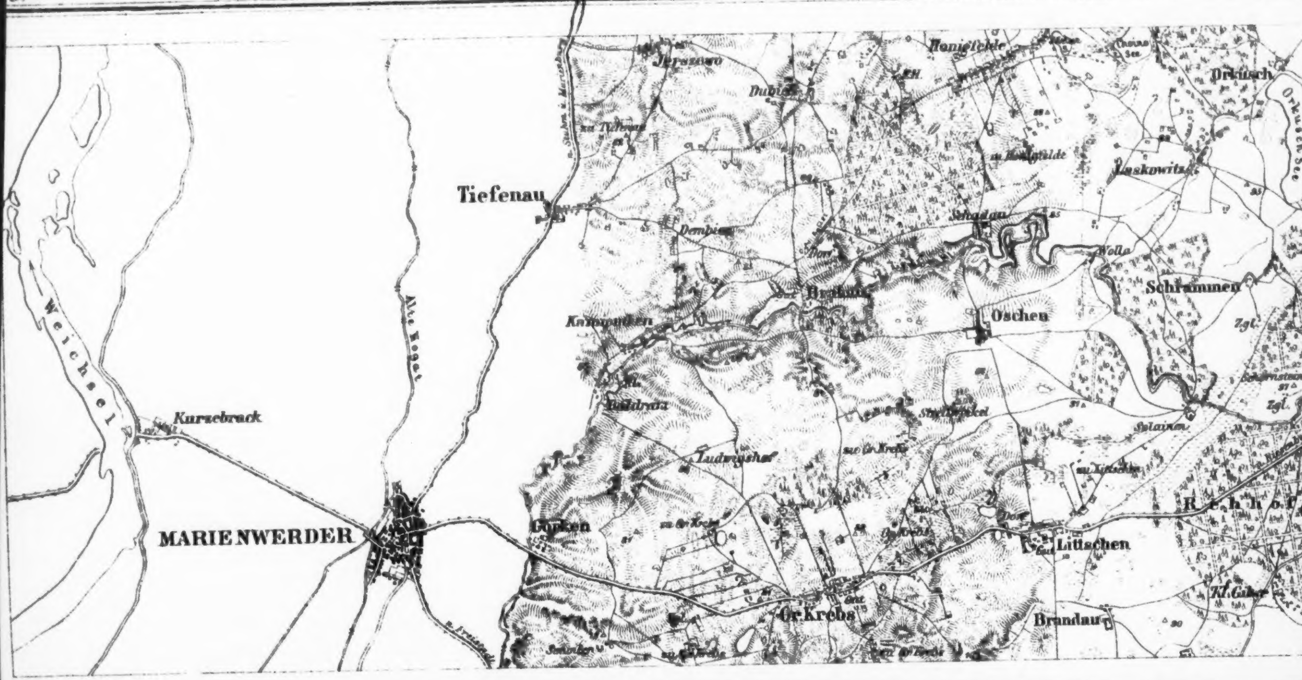
LONSDALE HALE.

al R.U.S. Institution.

3.

Karte zu den Uebungen der komb. Kavallerie-Division bei Marienwerder 1878.

Pl. XXXII



"L'AVENIR MILITAIRE."

But whilst the *Revue* thus exposes in the most public manner the customs and institutions of other nations, it is silent with regard to what is taking place in France itself. For information of this nature we must look elsewhere; and in *L'Avenir Militaire*, a newspaper issued every five days, we shall find very much of it. *L'Avenir Militaire* is a military journal of the ordinary character, but contains, besides original articles, the proceedings of the French Legislature, so far as they affect the Army, and also most of the decrees and orders issued from time to time.

The yearly subscription, not including postage, is 17 francs. The address of the management is 13, Quai Voltaire, Paris.

MANŒUVRES OF THE COMBINED CAVALRY DIVISION OF THE FIRST ARMY CORPS AT MARIENWERDER, FROM THE 23rd AUGUST TO THE 4th SEPTEMBER, 1878.

Translated by permission of Lieutenant-General V. Witzleben, from the eleventh part of the Appendix to the Militair-Wochenblatt. By Major Chenevix Trench, 20th Hussars.

In pursuance of an order of the Imperial Cabinet, dated April 5th, 1878, the assembly of the five cavalry regiments of the 1st Army Corps, and of the 5th Pomeranian Hussars (Blucher's Hussars) from the 11th Army Corps, and a detachment of East Prussian Horse Artillery for a ten days' course of manœuvring both in brigade and a division, was ordered to take place on the right bank of the Vistula. General Von Drigalski, the commander of the 2nd brigade of the Guard, was entrusted with the sole direction of these manœuvres, which were to be carried on from the 23rd of August till the 4th of September.

With due regard to the conformation of the terrain, the state of the crops, and the facilities for providing accommodation for the troops, a tract of land between Marienwerder and Riesenberg, on both sides of the river Vistula, was chosen as the scene of operations.

In consequence of the unusually heavy rainfall during the last week in August, the portion of the ground that lay to the north of the river Liebe was necessarily abandoned; as this tract comprised a good deal of rough and heavy ground, it had became so soaked with water, that the manœuvring of cavalry and artillery over it at any pace was quite out of the question. Owing to this cause, therefore, the manœuvres were, with the exception of the two first days for brigade exercise, carried out in the somewhat restricted space between the river Liebe and the road from Marienwerder to Riesenberg.

It was directed that during the march to the scene of the manœuvres the duties of reconnaissance and outposts should be practised on a large scale by the regiments under the command of the brigade com-

manders. In spite of the exertions entailed on the troops by these duties, which were in some cases severe, they all reached their cantonments in very good condition.

On the day of their entry into quarters at Marienwerder, the following "order of battle" came into effect. As up to this time the brigades had had no opportunity of manœuvring in their to some degree new organization (*i.e.* with regiments that had not yet worked together), two days were allowed them for practice in manœuvring, as the units of which the division was composed.

"Order of Battle."

Of the combined cavalry division of the 1st Army Corps.

Commander Major-General Von Drigalski, Commanding the 2nd Cavalry Brigade of the Guard.

General Staff Officer,—Major Freiherr Von Stosch.

Adjutant,—Captain Von Knebel Doeberitz.

1st Line.

Commander,—Major-General Arent.

12th Lithuanian Uhlans.

3rd East Prussian Cuirassiers.

2nd Line.

Commander,—Major-General Von Waldow.

8th East Prussian Uhlans.

1st Hussars of the Guard.

3rd Line.

Colonel Von Bomsdorff.

5th Pomeranian Hussars (Blucher's Hussars).

1st Lithuanian Regiment of Dragoons. Prince Albrecht's.

Detachment of the 1st Regiment of East Prussian Horse Artillery. (12 guns.)

On the 26th and 27th August, while paving the way for the execution of the general ideas that would have to be carried out in the manœuvres that were to follow, the brigades that were provided with artillery were entrusted with tasks similar to those which in war would devolve upon such detached bodies. On these occasions the formation in different "Lines" on a small scale was made a special feature, and an opportunity was thereby afforded to the regimental commanders for independently handling their regiments, as each corps formed one of these lines of its brigade.

In the arrangements for manœuvring the division, the main principle held in view was to manœuvre the great mass of cavalry as one compact body which, when thrown into the scale at the proper moment, might bring its full weight to bear in the manner best calculated to secure a decisive success.

Duly bearing in mind the great friction which so large a body of troops has to overcome, only the simplest manœuvres and evolutions were practised, which could with advantage, be carried out in the presence of the enemy. During the period of preliminary practice,

therefore, it was a great object only to represent the simplest formations. It was intended, however, that Officers and men should so perfect themselves in these, that at any moment, on any ground, and under all conditions, they might put them into practice, and that their correct execution might be reckoned on with certainty.

The execution of the manœuvres was based solely on the prescribed regulations for the cavalry drill. The instructions contained in Section VIII formed an excellent guide, by which to regulate the manœuvres of a cavalry division. The movements themselves were carried out without any previous explanation or programme being given out of the dispositions that were to be made.

All that was made known to Officers and men the previous day, were the general and special ideas, and the appointed rendezvous. This much being given to work upon, the different bodies of troops were directed by short verbal orders. These orders were carried by orderly Officers who always had to repeat the tenour of the order before riding off with it.

General idea for the manœuvres of the combined cavalry division of the 1st Army Corps, on the 26th, 27th, and 30th August, and the 2nd, 3rd, and 4th September, 1878:—

An army from the east is advancing with a broad front towards the Vistula. In order to protect its right flank, instructions are given to its easternmost corps, and a cavalry division to march by Deutsch Eylau towards Marienwerder.

A western army, about to deploy at Konitz, has for the protection of the eastern railroad and the lower Vistula formed a western corps to the south of Marienberg.

The foregoing general idea was applicable for the whole period of the manœuvres, except for the 31st August, on which day his Imperial and Royal Highness the Crown Prince was pleased to be present at the manœuvres of the combined cavalry division of the 1st corps which began at Marienwerder.

In order to represent the marked enemy, there was always a squadron composed of the 5th Pomeranian Hussars and the 12th Lithuanian Uhlans detailed under the command of Major Freiherr von Hammerstein.

Before giving a detailed account of what was done on each day, it may be as well to mention some general regulations and instructions, which were issued on the spot, and which were found to work well.

1. When the ground was very undulating, the necessity was recognised of having each attacking line followed up by a supporting squadron. If this rule appears superfluous on level parade grounds, it is by no means so when the ground is at all broken or undulating, as in such cases it is not always so easy to maintain the right direction. It was therefore prescribed that whenever a line advanced to the attack without having any squadron from the line in rear of it told off in support, this support must then be taken from its own strength. These supporting squadrons very often find it incumbent on them to close up into the attacking line.

2. The formation of the second Line in "regimental column with

manders. In spite of the exertions entailed on the troops by these duties, which were in some cases severe, they all reached their cantonments in very good condition.

On the day of their entry into quarters at Marienwerder, the following "order of battle" came into effect. As up to this time the brigades had had no opportunity of manœuvring in their to some degree new organization (*i.e.* with regiments that had not yet worked together), two days were allowed them for practice in manœuvring, as the units of which the division was composed.

"Order of Battle."

Of the combined cavalry division of the 1st Army Corps.

Commander Major-General Von Drigalski, Commanding the 2nd Cavalry Brigade of the Guard.

General Staff Officer,—Major Freiherr Von Stosch.

Adjutant,—Captain Von Knebel Doeberitz.

1st Line.

Commander,—Major-General Arent.

12th Lithuanian Uhlans.

3rd East Prussian Cuirassiers.

2nd Line.

Commander,—Major-General Von Waldow.

8th East Prussian Uhlans.

1st Hussars of the Guard.

3rd Line.

Colonel Von Bomsdorff.

5th Pomeranian Hussars (Blucher's Hussars).

1st Lithuanian Regiment of Dragoons. Prince Albrecht's.

Detachment of the 1st Regiment of East Prussian Horse Artillery. (12 guns.)

On the 26th and 27th August, while paving the way for the execution of the general ideas that would have to be carried out in the manœuvres that were to follow, the brigades that were provided with artillery were entrusted with tasks similar to those which in war would devolve upon such detached bodies. On these occasions the formation in different "Lines" on a small scale was made a special feature, and an opportunity was thereby afforded to the regimental commanders for independently handling their regiments, as each corps formed one of these lines of its brigade.

In the arrangements for manœuvring the division, the main principle held in view was to manœuvre the great mass of cavalry as one compact body which, when thrown into the scale at the proper moment, might bring its full weight to bear in the manner best calculated to secure a decisive success.

Duly bearing in mind the great friction which so large a body of troops has to overcome, only the simplest manœuvres and evolutions were practised, which could with advantage, be carried out in the presence of the enemy. During the period of preliminary practice,

therefore, it was a great object only to represent the simplest formations. It was intended, however, that Officers and men should so perfect themselves in these, that at any moment, on any ground, and under all conditions, they might put them into practice, and that their correct execution might be reckoned on with certainty.

The execution of the manœuvres was based solely on the prescribed regulations for the cavalry drill. The instructions contained in Section VIII formed an excellent guide, by which to regulate the manœuvres of a cavalry division. The movements themselves were carried out without any previous explanation or programme being given out of the dispositions that were to be made.

All that was made known to Officers and men the previous day, were the general and special ideas, and the appointed rendezvous. This much being given to work upon, the different bodies of troops were directed by short verbal orders. These orders were carried by orderly Officers who always had to repeat the tenour of the order before riding off with it.

General idea for the manœuvres of the combined cavalry division of the 1st Army Corps, on the 26th, 27th, and 30th August, and the 2nd, 3rd, and 4th September, 1878:—

An army from the east is advancing with a broad front towards the Vistula. In order to protect its right flank, instructions are given to its easternmost corps, and a cavalry division to march by Deutsch Eylau towards Marienwerder.

A western army, about to deploy at Konitz, has for the protection of the eastern railroad and the lower Vistula formed a western corps to the south of Marienberg.

The foregoing general idea was applicable for the whole period of the manœuvres, except for the 31st August, on which day his Imperial and Royal Highness the Crown Prince was pleased to be present at the manœuvres of the combined cavalry division of the 1st corps which began at Marienwerder.

In order to represent the marked enemy, there was always a squadron composed of the 5th Pomeranian Hussars and the 12th Lithuanian Uhlans detailed under the command of Major Freiherr von Hammerstein.

Before giving a detailed account of what was done on each day, it may be as well to mention some general regulations and instructions, which were issued on the spot, and which were found to work well.

1. When the ground was very undulating, the necessity was recognised of having each attacking line followed up by a supporting squadron. If this rule appears superfluous on level parade grounds, it is by no means so when the ground is at all broken or undulating, as in such cases it is not always so easy to maintain the right direction. It was therefore prescribed that whenever a line advanced to the attack without having any squadron from the line in rear of it told off in support, this support must then be taken from its own strength. These supporting squadrons very often find it incumbent on them to close up into the attacking line.

2. The formation of the second Line in "regimental column with

" deploying intervals " (*a*), was found to be a practical and handy formation until the first Line deployed.

At this juncture, or when the first Line came under the enemy's fire, the second Line had to adopt the formation of " column of " squadrons " (*b*).

The third Line was then most conveniently formed up in " regi- " mental column without deploying intervals " (*c*).[1]

3. The squadrons for the advanced guard, which was generally composed of two under a staff Officer, were taken from the first Line, and on the attack made an onset on that wing of the enemy against which the second Line could not act.

4. The decisive attack by several brigades in line, which is prescribed in Para. 222 of the " Cavalry Regulations," was carried out in two-fold fashion, viz. :—

(1.) After each brigade had taken a regiment for the first Line, the second regiment followed (in the same manner as a supporting squadron), as the second Line directly in rear of the first, and attacked on the same front the same body of the enemy which has been ridden over by the first échelon.

(2.) The second method consisted herein, viz. : the second Line followed the first, outflanking it, and while at the gallop in open column of squadrons formed oblique échelon, as soon as the gallop had been sounded for the line in front. The attack of the second Line thus took place in rear of the first Line, but in an oblique direction and in oblique échelon of squadrons. The second method of carrying out the attack had this advantage, viz. : that the weight of the shock of the second Line was not broken by the overthrown and fallen men and horses of the first Line.

THE 29TH AUGUST.

Of the six days that were available for the manœuvres of the division, the first was devoted to the simple evolutions prescribed for

[1] NOTE BY TRANSLATOR.—The Prussian terms of formation are given here literally translated, as we have nothing precisely corresponding to them. They are, however, correctly represented as follows :—

(*a*)

(*b*)

(*c*)

the division. On this account, no kind of general idea or programme for a fight was given out. The marked enemy had at a given moment only to post himself as a target for an attack directed against him.

The rendezvous was to the east of Gorken, immediately north of the Marienwerder-Riesenberg road, fronting towards the latter place—

First Line	..	..	..	Arent's Brigade.
Second Line	..	..	..	Waldow's do.
Third Line	..	..	..	Bomsdorff's do.

The Artillery in rear of the First Line.

The regiments in each Line were formed in regimental column without deploying intervals.

In this rendezvous formation, some movements to the front and flank were carried out in order to give the troops a sense of cohesion, and to accustom them to work together. It must, moreover, often happen that the division leader must lead his troops in a compact formation to the spot where he intends to deploy them in fighting formation and to make use of them.

When the component parts of a division had subsequently, by the sending out of an advanced guard, been separated, so as to have some practice in the management of the different lines, and in maintaining the correct distances, some changes of direction were carried out.

In the attacks that followed these movements, the first Line attacked to the front, the second Line made a flank attack with the regiment on the inner flank, and, with the corps on the outer flank, a movement to protect its own flank. The third Line remained meanwhile drawn up in column of squadrons, at the disposal of the divisional commander. After a short pursuit by the first Line, the division was drawn up again in a forward position towards the front in the regular three-line formation; and then a change of front was made which involved the different Lines changing their respective *rôles*. With this new front, an attack was now delivered on which the first Line was disengaged by the second. The third Line had to observe the front that had been abandoned, and in a flanking position covered the first Line as it retreated.

There followed now a retirement, which was executed by each of the Lines retiring successively, and an attack upon infantry was carried out. In this latter movement, two brigades attacked side by side, each brigade being formed into two lines. The third brigade eventually took part with one regiment in this fight. The artillery was pushed forward to prepare the attack for changes of front; its place was upon the inner flank.

The 30th August.

The general idea (the same as already specified).

Special Idea.

The western corps (marked enemy).

The western Army Corps has with the heads of its columns reached

Marienwerder, having come from Stuhm, and is about to deploy. The cavalry, six regiments, and one battery, has to protect the left flank of the line, to hold back the enemy's cavalry from the river Liebe and to reconnoitre the country towards the south. It had also to cross the Liebe at Brakau and Schadau.

The eastern corps (cavalry division).

The eastern force that has this morning started from the neighbourhood of Freistadt and Jankowitz (on the road Freistadt to Graudenz), in the direction of Marienwerder, has sent its cavalry division towards Littschen with instructions to cover the right flank of the force, to throw back the enemy's cavalry, and to gain possession of the passages over the Liebe. At 9 o'clock A.M., the division is drawn up with Von Waldow's and Von Bomsdorff's brigades, and the detachment of Horse Artillery at Littschen, and with Arent's brigade at Solainen.

Rendezvous.

The division stands on the 30th August at 9 o'clock, dismounted, and at ease, at the following points :—

1. Arent's brigade west of Solainen on the road from Ochsen in column of route, fronting towards the latter place, with one squadron pushed forward as an advanced guard up to the wood. A good look-out is kept in the direction of Ochsen.

2. Von Bomsdorff's and Von Waldow's brigades west of Littschen, fronting towards the road Marienwerder-Riesenberg, in column of squadrons side by side.

Von Bomsdorff's brigade, which pushes forward a squadron as an advanced guard over the sloping meadows in the direction of the Liebe as far as the small clumps of wood to the south of the road Gr. Krebs-Solainen, stands upon the right wing.

The detachment of Horse Artillery is drawn up in rear of Von Bomsdorff's brigade.

The Officers of my Staff will point out the precise places of rendezvous on the spot.

(*Signed*) V. DRIGALSKI.

Execution of the "Special Idea."

The division crossed in three separate columns the low-lying meadows that lay before it as follows :—

Von Bomsdorff's brigade and the horse artillery detachment on the road from Littschen to Ochsen.

Von Waldow's brigade upon a road that had been reconnoitred between Littschen and Gr. Krebs.

Arent's brigade upon the road Solainen-Ochsen. Whilst they were debouching, the advanced guard squadron announced the approach of the enemy's cavalry at the passages over the Liebe at Brakau and Schadau.

The 1st division was formed to the south of Ochsen with the road Gr. Krebs-Solainen along the front. It was drawn up in three lines as follows :—

First Line .. .. Von Bomsdorff's brigade.
Second Line.. .. Arent's do.
(Overlapping on the right.)
Third Line .. .. Von Waldow's brigade.
(Overlapping on the left.)

The detachment of Horse Artillery in rear of the first Line.

A hostile cavalry brigade north-east of Ochsen, *en route* towards the south, was in sight. It was conjectured to be the body of troops covering the left flank of a hostile cavalry division at Brakau, which was approaching the Liebe.

The Horse Artillery, under escort of the advanced guard squadron of Von Bomsdorff's brigade, is pushed forward to a range of hills south-west of Ochsen, whilst the division formed up, as has just been shown, advanced to the attack.

The first Line was disposed for the front attack, the second was intended, after having furnished supporting squadrons to the first Line, with a part of its strength to attack the left flank of the enemy's cavalry. The third Line had on this occasion to follow, and was instructed especially to keep a sharp look-out on the left front.

At 9.51 the attack on Ochsen was carried out with success in the way that had been ordered.

The second Line had two squadrons of Cuirassiers as supporting squadrons, and took part in the attack with the other two squadrons of this regiment, and with the squadron that had hitherto been acting as advanced guard of Arent's brigade. Three squadrons of the 12th Lithuanian Uhlans were kept on Reserve on the right wing.

The third Line reached as far as the south of Ochsen.

After a *mêlée* had taken place, the first Line undertook the pursuit in the direction of Schadau.

After this brigade had been rallied, one squadron was specially told off to follow up and maintain the touch of the defeated enemy.

The division was now intended to continue its reconnaissance in the direction of Brakau, and was ordered to make a change of front (changing the *rôles* of the different lines[1]) towards the left flank, while still maintaining the direction of the march towards Brakau.

The division was now distributed as follows, viz. :—

Von Waldow's brigade—First Line.

Arent's brigade, overlapping the left—Second Line.

Von Bomsdorff's brigade, overlapping the left—Third Line.

When some little distance had been traversed in a forward direction, detachments of the enemy's division that had crossed the Liebe at Brakau appeared in the Brakau ravine. A hostile battery now played upon the line of march.

The Horse Artillery was directed to open fire against the enemy who had just appeared, and at 10.25 the division by a change of direction upon the directing squadron of the first Line marched towards the enemy. The superior weight of artillery forced the enemy to retire

[1] Note by Translator.—*E.g.*, the brigade which previously formed the third line assumed the *rôle* and functions of the first line; the brigade which was previously the first line, that of the second line, &c., &c.

towards Ludwigshof. The cavalry on this side followed, and after passing the Brakau defile deployed for attack.

At 10.34, the encounter followed to the east of Ludwigshof, a front attack was carried out by the first Line, on which the advanced guard squadron operated against the enemy's left flank.

The second Line, rendered secure by its own outer wing, made a flank attack against the enemy's reserves (*i.e.*, the enemy's second line which was following in rear of his right wing).

The third Line held itself ready for action, and reconnoitred towards the mouth of the river Liebe.

The attack succeeded. The enemy pursued by the first Line retreated in the direction of Kamiontken.

The pursuit was brought to a stand-still by a fresh cavalry regiment of the enemy appearing in a position on the flank. The division was re-formed with its direction of march again on Kamiontken with the normal distances between the different lines. Meanwhile, the artillery played upon the retreating foe.

At Ludwigshof it was announced that the eastern corps had taken Marienberg, and that the enemy was retiring along the road to Stuhm. It had been intended that the cavalry division should cross the Liebe in several columns in order to break through the enemy's line of retreat. The ground, however, had been rendered so marshy in consequence of heavy rain, that great fatigue had been already entailed upon the horses, and the field-day was therefore brought to a close on the plateau of Ludwigshof.

31st August.

General Idea.

A western army intends to cross the Vistula, between Marienwerder and Graudenz. An eastern army stands ready in the neighbourhood of Osterode,[1] to oppose the western army as it debouches across the Vistula.

Special Idea.

The eastern army (represented by a marked force).

For the protection of the railway from Marienberg to Riesenberg, on which reinforcements of men and material are being conveyed, a cavalry division (4 regiments and a battery) has been stationed in Riesenberg. This division has with its outposts occupied the line. Honig felde Schadau Oschen, Littschen and Brandau. On the announcement that the enemy had pushed forward his reconnaissance towards the Vistula, that on the 30th August troops had entered Marienwerder, the commander of the division received the order to advance towards this town, and to reconnoitre the country as far as possible up to the Vistula.

For the support of the cavalry, three battalions of infantry will enter Schadau early on the 31st August.

The western army (cavalry division).

[1] Ten miles to the south-east of Marienwerder, and not included in the map.

The advanced guard of left wing of the western army has, on the 30th August, crossed the Vistula at Kurzebruck, and taken possession of Marienwerder.

The transfer of the remaining portion of the force across the river is arranged to take place on the 31st August. The cavalry division receives instructions to reconnoitre on the 31st August towards Riesenberg and the river Liebe.

Rendezvous.

The division stands on the 30th August, at 10 A.M., immediately south of the road Marienwerder-Riesenberg, north-east of the advanced work at Semmler, fronting towards the north, in readiness to march. The three brigades are drawn up with each regiment in regimental column without deploying intervals. Arent's brigade upon the right wing; nearest to it Von Waldow's brigade and then Von Bomsdorff's, the artillery upon the left wing.

The exact positions are to be shown on the spot by the General Staff Officer of the division.

(*Signed*) V. DRIGALSKI.

Execution.

The division was led forward in a compact body from its place of rendezvous, in the direction of Tiefenau, and then it was deployed and drawn up in different lines, as follows:—

First Line, Von Waldow's brigade, with two squadrons of hussars as an advanced guard.

Second Line, Arent's brigade (overlapping the first on the right).

Third line, Von Bomsdorff's brigade (overlapping the first on the left).

The artillery detachment in rear of the first Line.

At 11 o'clock the outposts which were stationed on the line from Brakau to Gr. Krebs reported that they had been attacked upon their left, and that they had been pressed by a superior force of the enemy's cavalry from Brakau.

By means of a change of direction half right the division gained the direction towards Brakau. Upon the plain between Brakau and Ludwigshof, the heads of the columns of a large body of the enemy's cavalry were visible, which had been making a reconnaissance towards Marienwerder. The horse artillery was pushed forward under the protection of the advanced guard, as far as immediately north of Ludwigshof, and opened fire on the enemy.

At 11.16 Von Waldow's brigade went in a westerly direction round Ludwigshof to attack the enemy, who showed a front of six squadrons strong, whilst the second Line, making a detour to the east, round Ludwigshof, with one regiment, made a flank attack against the enemy's second Line (consisting of three squadrons), and with the other had to manœuvre, so as to protect and cover the flank.

The third Line furnished two supporting squadrons to the first Line, and remained north-west of Ludwigshof in readiness to act. The enemy's cavalry was defeated and was pursued by the first Line. The

latter was, however, recalled by the trumpet-sound, as it came under fire of the enemy's infantry, which in order to succour its own cavalry had occupied the heights, south-west of Brakau wood. The artillery of this side (western army) played upon the Brakau wood, and the cavalry division was drawn up to the east of Ludwigshof.

During this time, a communication was received from the western army that an infantry brigade, advancing up the valley of the Liebe, had passed Kamiontken, and intended to clear Brakau of the enemy.

It was intended that the division should now, in accordance with instructions received, reconnoitre in the direction of Riesenberg. It executed a change of front to the right, by transposing the *rôles* of the different lines, and at 11.30 advanced in the new direction.

First Line—Arent's brigade.

Second Line—Von Bomsdorff's brigade.

Third Line—Von Waldow's brigade.

In order to secure the retreat of the infantry of the 1st eastern army who were fighting in the Brakau wood, a cavalry brigade of the enemy (10 squadrons strong) appeared among from Streitwinkel in several lines.

While the cavalry of the western army advanced against the enemy, the detachment of horse artillery prepared the attack by its fire. At 11.45 Arent's brigade attacked in front, Von Bomsdorff's brigade (second Line), delivered an attack with the 5th Hussars against the enemy's reserves. Prince Albrecht's regiment of dragoons followed as a protection upon the right flank, and had here to encounter inferior forces. Von Waldow's brigade (third Line), kept up the communication with the infantry of the western army, and remained at the disposal of the division leader. The attack made by this side (western army), succeeded. The pursuit over the Brakau ravine was, however, checked by the enemy's artillery fire from Oschen. Von Bomsdorff's brigade and the artillery followed as far as Streitwinkel and ascertained the fact that the enemy's cavalry remained at Oschen.

The horse artillery detachment, from a position to the south of Streitwinkel, played upon the Brakau wood in which the fire of the infantry was audible, and upon the enemy's artillery.

Arent's and Von Waldow's brigades, screened from sight in the ravine north of Streitwinkel, were now led to the houses at the eastern end of the place, in order that from this point they might be able to hinder the retreat of the enemy's infantry out of the Brakau wood.

At 12.5 the infantry of the eastern army was forced by the attack from the north, which threatened to envelop them on all sides, to abandon the Brakau wood, and to retreat upon Oschen. The cavalry division took advantage of this movement. Arent's and Von Waldow's brigades, concealed in the ravine, were drawn up side by side with each brigade in two lines for a decisive attack upon the infantry, and at 12.10 issued forth to carry it into execution.

The hostile cavalry, which was drawn up near Oschen, wished to attack our right wing, but had its left wing rolled up by Von Boms-

dorff's brigade, which, followed in rear, outflanking the right of the two attacking brigades.

In conclusion, two hastily rallied squadrons of the 12th Lithuanian Uhlans were sent off to capture a battery at Oschen, which had been posted without any adequate protection.

September 2nd.

General Idea.

The same as already specified.

Special Idea.

The cavalry division has received instructions from its own western army, which is at Stuhm, to advance in the direction of Littschen against the eastern army, which, since the 30th August, has occupied Marienwerder. For the purpose of carrying out these instructions, the division, at 9 A.M. on the 2nd September, crosses the Liebe at Schadau, and stands on the road Schadau-Oschen ready for a further advance.

Rendezvous.

The division stands, at 9 A.M. on the 2nd September, south of the river Liebe on the road Schadau-Oschen; the front is towards the south. The regiments will be drawn up with squadrons in close column of divisions without deploying distance. Arent's brigade to the west, and Von Bomsdorff's brigade to the east of the above-named road. Von Waldow's brigade as an advanced guard, north of Oschen, with two squadrons pushed forward with instructions to reconnoitre towards Ludwigshof, Littschen, and Solainen.

The detachment of horse artillery is drawn up in rear of Von Waldow's brigade.

(*Signed*) V. DRIGALSKI.

Execution.

On this day no special idea was given out for the marked enemy; the latter received on the ground brief instructions as to the positions to be taken up, from the Officers of the general staff attached for this purpose.

At 9.9 the advanced guard announced the presence of a strong mass of cavalry at the eastern exit from Streitwinkel, which was marching upon Oschen.

Under the protection of the advanced guard, which was advancing as far as Oschen, and was composed of Von Waldow's brigade, the horse artillery took up a position to the west of Oschen.

It was determined to advance with the advanced guard against the enemy's front, and with the main body against his right wing. Eventually, Arent's brigade was drawn up to the east of Oschen as the first Line, Von Bomsdorff's brigade, outflanking the left, as the second Line. The front was towards the south.

At 9.15 the advanced guard issued forth from the west of Oschen

(where it had hitherto stood alongside the artillery hidden from sight by the rising ground), against the enemy's cavalry, in order to protect its own artillery. Von Waldow's brigade, however, was obliged to retreat out of the *mêlée* before the superior strength of the enemy.

Arent's brigade, which going round to the east of Oschen, confronted the right flank of the enemy, succoured Von Waldow's brigade at this moment by means of an attack in échelon formation. Von Bomsdorff's brigade on the outer wing made a movement with Arent's brigade and maintained a look-out in the direction of Littschen.

The enemy, in consequence of the diversion effected by Arent's brigade, was obliged to withdraw to the north of Gr. Krebs, and the pursuit was carried out by Arent's brigade. The artillery was now pushed forward on the height to the north of Streitwinkel.

At 9.30 the reconnoitring patrols on the right flank announced that hostile cavalry and artillery were in sight, from Marienwerder in the direction of Brakau. Thus threatened on its right flank, the division made a change of front to its right, which was carried out by the Lines changing their respective *rôles*. The artillery of the cavalry division, from the position it had temporarily taken up, opened upon the enemy, who had appeared in the Brakau ravine, and who had posted a battery to the south of the Brakau wood.

As, however, the enemy's troops again showed themselves in the wood of Gr. Krebs, the division leader determined to retire over the right bank of the Liebe, but before doing so, to gain a little time by means of an attack to the front.

Von Bomsdorff's brigade and the artillery detachment were therefore sent back over the right bank of the Liebe to shelter the division. The passage both at Schadau and at Wolla was protected by dismounted skirmishers.

Von Waldow's and Arent's brigades then advanced against the enemy, the former brigade with its inner regiment pushed forward to the front, and with the other on the left flank; Arent's brigade made with its inner regiment a flank attack, and with its outer regiment protected the movement against the enemy in the Gr. Krebs wood. The masked enemy was defeated. At 9.55 Arent's brigade was taken back as far as the south of Oschen, while Von Waldow's brigade withdrew itself (one regiment at a time), from before the increasing strength of the enemy in such a manner that one regiment retired in line straight towards the north-east point of Oschen, and the other in an échelon formation in the same direction. It thus retained its power of acting (if necessary), against the left wing of the enemy.

At the north-east point of Oschen, Von Waldow's brigade covered the further retreat of Arent's brigade upon Wolla, by taking up a position on the flank, and then crossed over the Liebe at Schadau.

At 10.25 the enemy, pressing forward in greater strength, attacked Arent's brigade between Oschen and Wolla, but was driven back by the opportune intervention of the hussar regiment of the Guard, which happened to be still on this side of the river Liebe.

The division now bivouacked with its main body on the Orkusch Lake, and with the bulk of the advanced guard, consisting of the 5th Pomeranian Hussars, a horse artillery battery, and a pioneer detachment, at Laskowitz. The outposts furnished by Prince Albrecht's dragoon regiments secured the section of the Liebe (that had to be guarded), by dismounted men and outlying picquets.

The villages of Brakau on the right, and Schrammen on the left, were occupied with as strong a force as necessary. The outposts of the masked enemy were posted opposite to those of the cavalry division upon the line, Brakau farm-Oschen-Solainen.

3rd September.

General Idea.

The same as already specified.

Special Idea.

Eastern corps (marked enemy). After the fight on the 2nd September, the cavalry of the west corps is obliged to retire over the river Liebe. The passages across at Wolla and Schadan are in the enemy's hands.

The eastern corps has occupied Marienwerder, and the passages of the river upstream as far as the Brakau farm, and made arrangements for defending its position.

Western corps (cavalry division). The western corps, with all its disposable forces, will advance to the attack against Marienwerder.

The cavalry division is to support the attack by operating against the enemy's right wing.

Rendezvous.

Von Bomsdorff's brigade occupies the passages at Schadau and Wolla. The rest of the brigade and a battery are, at 8 A.M. on the 3rd September, concentrated in rear of the left wing. Reconnoitring is to be carried on towards the right flank. Arent's and Von Waldow's brigades stand with the horse artillery batteries, at 8 A.M. on September 3rd, to the south of Laskowitz in "regimental column without deploying "intervals."

Arent's brigade in first Line.

Von Waldow's brigade in second Line.

The artillery in rear.

The first Line holds communication with Wolla, the second Line secures the left flank.

(*Signed*) VON DRIGALSKI.

Execution.

At 9 A.M. the masked enemy advanced towards the passage over the river at Schadau, and pressed the picquets of the cavalry division, which belonged to the regiment of dragoons, back over the river Liebe. The attack was, however, repulsed by means of the fire of the dismounted men in conjunction with the artillery, which was posted to the north of Schadau.

The cavalry division leader determined, with Von Bomsdorff's brigade and the artillery, to hold first the issues over the Liebe in front, and with the other two brigades to advance against the right flank of the enemy.

Von Waldow's brigade therefore received the order to advance over a bridge, which had been thrown across the Liebe by the pioneers, to the south of Wolla, while Arent's brigade utilized the ford at Wolla with the same object in view. At 8.30 the two brigades were united on the southern bank of the river Liebe, Arent's brigade being the first Line, whilst that of Von Waldow's, overlapping the left, formed the second Line.

The hostile cavalry which had been posted to the south of Oschen, so as to be protected from the artillery fire of the western corps, now turned its attention to the two brigades. At 8.40 it advanced to the attack in such fashion that the first Line (Arent's), was opposed to the enemy's left wing, and the second Line (Von Waldow's), to his front.

Not only this attack, but the appearance of the heads of the columns of Von Bomsdorff's brigade, which had received orders to cross the river south of the Schadau defile, almost in the enemy's rear, forced the latter to retire to the south of Streitwinkel.

Arent's brigade undertook the pursuit. The division concentrated itself at Oschen, with its front to Streitwinkel. Arent's brigade formed the first Line, south of Oschen; Von Bomsdorff's brigade, the second Line north-west of Oschen; Von Waldow's brigade, the third Line outflanking the left of Arent's brigade. A good look-out was kept towards the road Marienwerder to Riesenberg.

The artillery detachment was in rear of Von Bomsdorff's brigade.

At 9 A.M. a report was sent in from the western corps, that it had taken Marienwerder and the passages over the Liebe, and that the enemy's infantry was retreating in the direction of Gr. Krebs.

The cavalry division now turned its attention to the latter, after that the artillery, from a position to the west of Oschen, had prepared the attack. Von Bomsdorff's and Arent's brigades, each arranged in two lines, came up to the hostile infantry, which consisted of three battalions, and attacked it.

Von Waldow's brigade outflanking the left, followed the course of the attack on third Line, watching the direction in which the hostile cavalry had withdrawn.

The division took up the direction towards the road Marienwerder-Gr. Krebs, and in order to do so, made a change of front by changing the respective *rôles* of the different lines.

Von Bomsdorff's brigade first Line (two squadrons advanced guard). Arent's brigade (outflanking the left), second Line. Von Waldow's brigade (also outflanking the left), third Line. The last named was employed on the look-out towards the wood of Gr. Krebs, which was occupied by the enemy. The artillery followed the first Line.

To the east of Ludwigshof the enemy's cavalry, who wished to secure the retreat of its infantry from Baldram towards Gr. Krebs, advanced to meet the division, and were attacked by it.

The first Line utilised an undulation in the ground, and under

cover of its own outer wing, attacked the enemy's left flank, while the second Line attacked his front.

4TH SEPTEMBER.

General idea (the same as already specified).

Special Idea.

Western corps (marked enemy).

The western corps has taken possession of Marienwerder and the passages over the Liebe, and wishes to make the most of the day's success by an energetic pursuit.

Eastern corps (cavalry division).

The eastern corps is forced to evacuate Marienwerder and the passages over the Liebe. It retreats on the road towards Freistadt, and on the road towards Jankowitz. On the cavalry division devolves the task of covering the retreat.

Rendezvous.

At 9 A.M. the two brigades and the detachment of artillery are to be drawn up to the north of Gr. Krebs. The precise position will be pointed out on the spot. The brigades to be drawn up in regimental column, without deploying intervals. Arent's brigade to be upon the right wing; Von Bomsdorff's brigade in the centre, with Von Waldow's brigade on the left; the artillery in rear of Von Bomsdorff's brigade. The latter brigade is to detach two squadrons to the northern edge of the coppice which lies in front of it. A good look-out to be maintained in the direction of Marienwerder and the Liebe.

(*Signed*) V. DRIGALSKI.

Execution.

In order to carry out its appointed task, the division advanced by three roads through the wood which lay before it in the direction of Kamiontken. Concealed by the conformation of the ground the troops were disposed as follows:—

Von Bomsdorff's brigade to the north of Gr. Krebs wood as first Line.

Arent's brigade (overlapping on the right), as the second Line on the Gr. Krebs-Brakau road at the corner of the wood.

Von Waldow's brigade, stationed at the western extremity of the wood, as third Line. On the announcement that the enemy's infantry from Kamiontken was advancing in the direction of Gr. Krebs, the detachment had followed Von Bomsdorff's brigade, and which had taken up a position on the left flank of the same, opened its fire. At 9.45 Von Bomsdorff's brigade advanced in two lines, the one immediately in rear of the other against the front of the enemy, whilst Arent's brigade concealed, in a ravine, was led forward against the left flank of the enemy in two lines similarly disposed. Von Waldow's brigade, overlapping the left, followed as third Line.

The attack was successful, and the pursuit was taken up by the first Line. This, however, could only be carried out as far as the high banks of the Liebe, as the fire of the enemy's skirmishers compelled

the brigade to rally to the rear. The division rallied to the east of Ludwigshof out of rifle range, and the battery of horse artillery, which had been pushed forward towards the front, opened fire upon the position occupied by the enemy.

The enemy's cavalry, which, coming from Oschen, wished to make a diversion in favour of its infantry, obliged the division in the quickest manner possible to change front towards the right.

By this movement the *rôles* of the different brigades were altered as follows, viz.:—

Arent's brigade—First Line.

Von Waldow's brigade—Second Line.

Von Bomsdorff's brigade—Third Line, overlapping on the left.

The latter brigade, by means of a short attack to the front, drove off some few of the enemy's skirmishers who still remained on the southern bank of the Liebe.

In going forward to the attack, Bomsdorff's brigade furnished two supporting squadrons in rear of the first line, and also took measures to keep a look-out in the direction of its former front, where the enemy's infantry was retreating.

As the hostile cavalry, which was appearing in the direction of the new front, extended its line on the right, two squadrons from the third Line were also thrown forward for the purpose of lengthening the front. At 10.5 the two lines met to the north of Streitwinkel.

The first Line (Arent's brigade) was, in spite of its extension of front, overthrown, and Waldow's brigade now struck in (as had been previously arranged), opportunely with a flank attack with the 8th Uhlans of the Guard, so as to make a diversion in favour of the first Line. The regiment on the outer flank (*i.e.*, of Waldow's brigade) were held back as a protection to the flank, in rear of the exposed wing of the 8th Uhlans.

The enemy now retired in the direction of Oschen before the superior forces that were now developed to oppose him.

Our eastern army had meanwhile reached Neudafchen and Kbostersee, and the division leader determined to retire also. Von Waldow's brigade therefore received instructions to occupy, with the Hussar regiment, the north-eastern portion of the Gr. Krebs wood, and with 8th regiment of Uhlans to cover the retreat of the division.

The artillery detachment was directed to take up a position at the north-eastern corner of the wood.

Arent's brigade was, on its movement to the rear, hard pressed by the enemy up to the Gr. Krebs wood, but having in conjunction with 8th regiment of Uhlans, at 10.30, by a short advance to the front, secured for itself a little breathing time, it changed its front. being protected by the northern end of the wood.

An advance of the enemy's cavalry from Streitwinkel was repulsed by the fire of the dismounted hussars and of the artillery.

The hostile cavalry, which was unwilling to pass the defiles of Littschen in sight of the division, intended apparently to advance by Ludwigshof in the direction of Gr. Krebs. This movement, during which the enemy laid open his flank to the division, was utilised by

the divisional commander, in order to advance once more from the position where he had found a temporary shelter. At 11 A.M., therefore, Arent's brigade moved forward to make a front attack against the enemy, who, to the south of Ludwigshof, was quickly developing his strength. Von Bomsdorff's brigade was directed against the right flank of the enemy, which was formed by his (*i.e.*, the enemy's) second Line. The 8th regiment of Uhlans followed as the third Line (of the division), overlapping on the right, and had, while covering the right flank of the division, to attack the hostile skirmishers in the direction of Brakau.

Each day, when the manœuvres were over, there was a march-past which, in accordance with instructions received, was always carried out at either the trot or gallop.

It may be mentioned that to the reports of the reconnoitring patrols great importance was attached. These were, in general, very good. From them, the strength of the masked enemy, the disposition of his different Lines, and information as to which wing was supported by a Line in rear of it, was correctly ascertained and reported. The éclaireurs also did their duty well in very rough ground, which was in some places cut up with ditches and turf-holes. The pioneer detachment attached to the division found scope for their services in throwing two bridges over the Liebe, and in rendering practicable several fords.

In conclusion, the conviction may here be expressed that only by the constant repetition of such manœuvres as these can a cavalry division be fitted for its *rôle* as the eyes of the General in operations on a large scale, as well as for the tasks which may devolve upon it in the actual battle-field.

Memorandum of some of the places named in the text, and not included in the map.

Marienberg	about	22	miles	N.	of	Marienwerder.
Riesenberg	,,	11	,,	E.	,,	,,
Deutsch Eylau	,,	28	,,	S.E.	,,	,,
Konitz	,,	55	,,	W.	,,	,,
Stuhm	,,	14	,,	N.	,,	,,
Freistadt	,,	16	,,	S.E.	,,	,,
Graudentz	,,	20	,,	S.	,,	,,

ON THE BEST MODE OF FIRING IN A NAVAL ENGAGEMENT.

(Translated from the *Revue Maritime et Coloniale* by Lieutenant HASTINGS LEES, R.N.)

Two different modes of firing on board men-of-war have been recognized for a very long time, the independent or fire by successive shots; and broadside fire, firing all the guns at once. When the first mode of firing is employed, it takes a certain time to send the same number of projectiles that are sent all at once by a broadside; besides the length of this time varies and depends on many circumstances. If the adversaries are stationary and can remain opposite each other during all the necessary time, there is no difference between the effect of the independent fire and the broadside. But if the adversaries only remain a very short time in such a position as to make it possible to utilize the firing, it is evident that the effect of successive firing, compared with the broadside, will be as much weakened as the propitious time for firing may be of shorter duration. This is at least what was generally admitted in the time of sailing ships. At this period, if an enemy's ship crossed ahead or astern, the whole broadside was sent into her without hesitation; on the contrary, the independent fire was used when the adversaries were side by side, and as it rarely happened that a ship could cross another ahead or astern, broadsides were rarely used.

When the screw-propeller was adapted to wooden vessels it became evident, by reason of their swiftness and the facility of their evolutions, that it could no longer be hoped to keep the adversary within the range of gun-shot. Every one was of opinion that, in fighting under steam, ships could only fire quickly as they passed each other without ever being able to fire for any length of time. This necessary consequence of fighting under steam turned the attention from broadside firing, and prevented its being brought to perfection.

Ironclads have not been inferior, with regard to speed, to the steamers which have preceded them; it is even endeavoured to increase considerably the speed of new armour-plated ships; nevertheless a broadside fire is a necessity when firing at armour-plated walls, for recent experiments have proved that instantaneous firing caused more considerable ravages, for an equal number of shots, than successive firing.[1]

Every effort is made now to obtain the simultaneity of loading, to fire all the guns exactly at the same moment; for it is believed that it is

[1] More recent and complete experiments made at Gavre by the Commission on Armour Plates have, nevertheless, led to a contrary conclusion.

an essential means of obtaining a maximum effect. This object could not be obtained if the broadside is prepared, as it is at the present time, by means of the sights. It is hardly possible that at a given moment all the guns should be exactly pointed at the mark; it is for this reason that a particular system of pointing has been devised, called converging firing.

For reasons which will be shown further on, converging firing was not so precise when compared with successive firing; and until quite lately, most naval Officers have admitted that successive firing with the sight was the most precise.

Thus, then, as a last resource, when firing, it was necessary to choose one of two things; either successive firing, more precise, but not permitting any reliance to be placed on a sufficient number of shots; or converging firing, the aim of which was not precise, as soon as the distance was rather great.

However, this opinion as to the precision of successive firing with the sight was solely based upon the results of experimental trials of firing against an immovable mark placed at a known distance, that is to say, under totally different circumstances from those which must be expected in a naval combat.

The aim of the present article is to show, that the influence of the most common and inevitable circumstances, in a naval combat, sometimes diminishes in a considerable degree that precision of successive firing, the impression of which has been only acquired from experimental practice; besides, to show that the precision of broadside firing has been increased by the adoption of more perfect instruments, and to which numerous improvements may still be made.

1. *Influence of the movement of vessels on the number of projectiles that reach them.*

To understand how the influence of the movement of ships in a combat bears upon the number of projectiles which reach them, it is necessary to imagine the manner in which the pointing is executed, and the firing effected.

When the distance is ascertained, the chief gunners have orders to adjust the sights corresponding to this distance, to point and fire as soon as ready. It is understood that from the moment in which the distance has been measured, to that in which the chief gunner points, that is to say, directs the line of aim on the centre of the objects, there is an interval of time, more or less long.[1] And as the two vessels have moved during this time, it is clear that at the moment when the line of aim passes through the centre of the object, the distance of the two vessels, in an immense majority of cases, will no longer be the same as that for which the sight was fixed. This is why, supposing that the gun is perfectly precise, that is to say, that at every shot fired with identical charges and projectiles, the projectile describes exactly the same trajectory, and the gun is fired just at the moment in which the line of aim passes through the centre of the object, nevertheless

[1] It is what we shall call in future, duration of pointing, or interval of pointing.

the projectile will not fall at this point; it will go higher or lower, because the distance between the two ships has diminished or augmented during the interval of pointing.

The distances between the two ships may, while the pointing lasts, augment, diminish, or even remain stationary, according to the relative disposition of the direction followed by the two adversaries, and the speed of their movements. Let in short A and B (Fig. 1) be the positions of the centres of the two ships at the precise moment in which the distance AB, which separates them, be known, and let us suppose that during the interval of the pointing they go over respectively the spaces A*a* and B*b*; if the lengths A*a* and B*b* are carried on to the direction followed by the ship at the moment of the coincidence of the line of aim with the centre of the object, the distance will be *ab*. Therefore it is easy to see from the drawing that *ab* may be $> AB < AB$, or $= AB$, according to the respective length of the quantities A*a* and B*b*, that is to say, according to the sailing of the two ships during the interval of pointing. Thus, if definite speed is allowed for the two ships, it is evident that the relation of the distance *ab* to the distance AB will depend upon the angles which are made with the right line AB by the directions traversed by the ships.

Let us suppose now that the curve $cb'OB''$ (Fig. 2) represents the trajectory of the projectile, corresponding to the definite distance to which the sight has been adjusted.[1] To simplify we will suppose, besides, that the height of the gun above the water CA is precisely equal to that of the centre of the object OB, *a*B, representing the height of the object. If we draw the horizontal line bb', and that by the points b' and B'', we draw the vertical lines $b'B'$ and $b''B''$, we shall see that if, during the time of pointing, the distance diminishes, the projectile will fall upon the object higher than the centre, but will still fall upon the object, provided that the distance does not vary to a greater extent than BB. It is easy to understand that the magnitude of the variation of the distance during the interval of pointing depends, in the first place, on the relative speed of the vessels according to the direction of the firing, and in the second place, on the exact value of that interval. Let us designate by T the value of the interval of pointing. By dividing the distance BB' or BB'' by the relative speed of the object in the direction of the firing, the interval of time at the end of which the object will be out of the range of shots will be obtained, by reckoning this time from the moment in which the distance begins to vary. If this interval, which we designate by T, is greater than the interval of pointing, it is evident that the projectile cannot reach the object. If, on the contrary, the time that the object would take to run through the space BB' or BB'' is less than the interval of pointing, the projectile will reach the object.

As for a like charge and like projectile the extent of the fire-angle $B'B''$ decreases in proportion as the distance augments, the result is

[1] In reality the curve of the figure 2 represents the projection of the trajectory on a vertical plane passing by the line of aim of the bridge. To abbreviate we call it the trajectory, that is to say, that we leave out the deviation, which may be allowed with a sufficient approximation to be four cables' lengths.

Fig 1

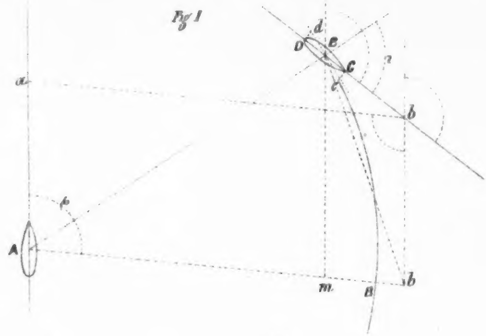


Fig 2

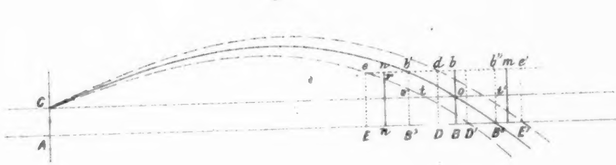


Fig 3

Fig 4

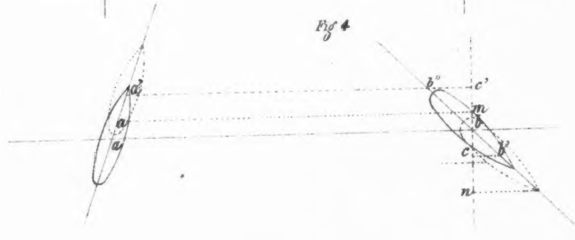


Fig 5

Fig 6

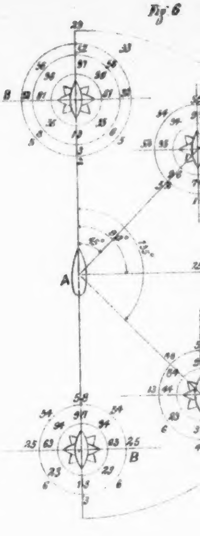


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Fig. 6

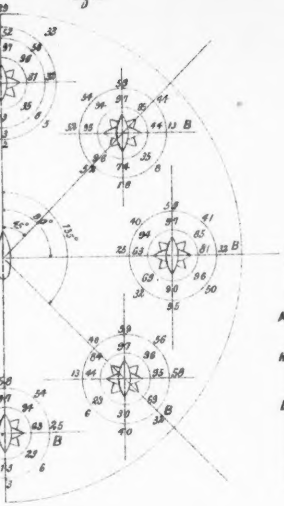


Fig. 7

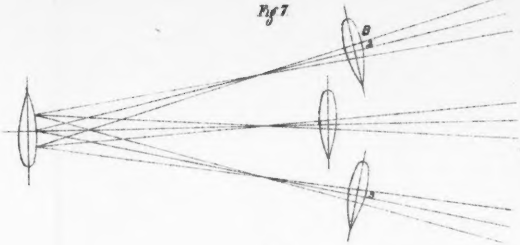


Fig. 8

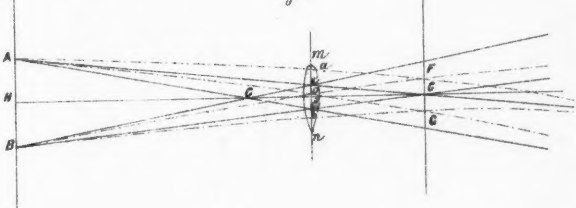


Fig. 9

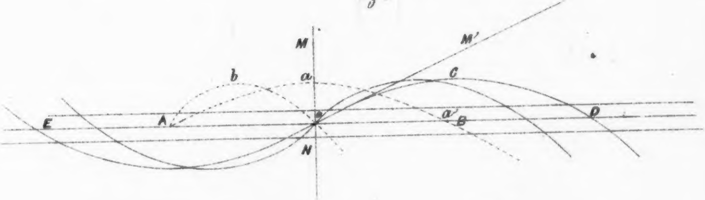


Fig. 11

Fig. 10

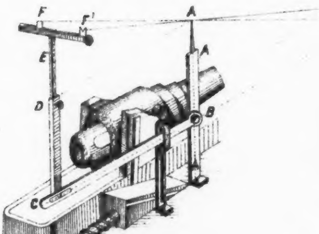
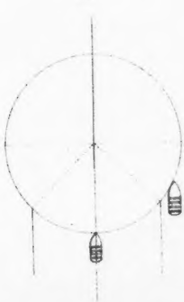


Fig. 12



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that, for the same relative speed in the direction of the firing, the interval of time that the object takes in going over this space also diminishes when the distance augments.

As the time of pointing for a gun of a given calibre may be considered as constant, whilst the time during which the object remains in the fire-angle changes with the distance of the object, with the direction and speed of the movable object, and also with the height of this object, the time during which the object will be exposed to the projectiles will be equal to the difference of the two others. It is that difference of the two times that we will call the *dangerous interval.* Evidently the dangerous interval will become nil when the time that the object takes in traversing the fire-angle will be equal to the duration of the pointing.

It is known that for each gun, and for a charge and a given projectile, the fire-angle diminishes in proportion as the distance of the object increases, and that for some distance it diminishes at the same time as the height of the object. Consequently, it is evident that for each gun, for a given height and relative speed, there is always a distance at which the dangerous interval is annulled. It may be readily understood that beginning the firing at this distance is useless; this distance, besides, decreases with the height of the object.

And more, it is to be observed that the greatness of the distance at which the shots from a perfectly precise gun ought to reach the object increases for the same gun with the weight of the charge, and for the same initial speed with the calibre of the gun; in either case the fire-angle also increases, and with it the dangerous interval, if, however, the duration of pointing remains the same. The relation between the fire-angle, the height of the object, and the inclination of the trajectory, may be approximately expressed in the following manner. Considering the arc of the trajectory $b'\mathrm{O}$ as a straight line, and the angle $b'\mathrm{O}o'$ as the angle where the projectile falls, which we will designate by θ, we have in the triangle $b'\mathrm{O}o'$.

$\mathrm{O}o' = \dfrac{b'o'}{tan\theta}$, from which we draw the condition that $\mathrm{O}o' t\theta$, ought to be less than $b'o'$, in order that all the shots should fall upon the object. The instances in which the shots from a perfectly precise gun fall, or do not fall, upon the object is seen very clearly on the Table I which is annexed, which indicates the intervals of time during which the enemy will be within the fire-angle, allowing that the combatants should be moving 10 knots, a speed which may be obtained from the present ironclads. These numbers are taken from an article written by an Italian Officer; they are calculated for the trajectory of a shell of 22 c.m., animated by an initial speed of 435 metres, and for a height of an object of 6 metres.

TABLE I.

Interval of time during which a vessel moving with a speed of 10 *knots remains in the range of the fire-angle of another ship moving at the same speed.*

Distance and Limits of Dangerous Interval.	Angle of bearing.	Angles between the two courses. Parallel. $\theta = 0$.	$\theta = -45$.	$\theta = -90$.	$\theta = -135$.	$\theta = -180$.	$\theta = +135$.	$\theta = +90$.	$\theta = +45$.
			′ ″	′ ″	′ ′	′ ″	′ ″	′ ″	′ ″
	$\phi = 0°$	Does not leave dangerous interval.	3 3+	2 12+	0 26−	0 20−	0 26−	2 12+	3 3+
D = 500 metres......	45°		1 2−	0 29−	0 26−	1 33+	1 7+	1 8+	1 25+
a = +201 metres...	90°		1 2−	2 12+	1 15+	0 48+	0 38+	0 35+	0 54+
b = −212 metres...	135°		3 3+	1 6+	0 35+	0 24+	0 22+	0 28+	0 54+
	180°		1 25+	0 35+	0 22+	0 20+	0 22+	0 35+	1 25+
	$\phi = 0°$		4 5+	0 19−	0 11−	0 9−	0 11−	0 19−	4 5+
D = 1,000 metres ...	45°		0 27−	0 13−	0 10−	0 13−	1 42+	1 0−	0 51+
a = + 92 metres ...	90°		0 27−	0 19−	1 40+	0 43+	0 15+	0 17+	0 25+
b = − 94 metres ...	135°		4 5+	1 1+	0 21+	0 12−	0 10+	0 13+	0 25+
	180°		0 51+	0 17+	0 10+	0 9+	0 10+	0 17+	0 51+
	$\phi = 0°$		0 42−	0 10−	0 6−	0 5−	0 6−	0 11−	0 42−
D = 1,500 metres ...	45°		0 16−	0 7−	0 6−	0 8−	0 18−	0 57+	0 34+
a = + 56 metres ...	90°		0 16−	0 10−	0 12−	0 40+	0 14+	0 11+	0 15+
b = − 56 metres ...	135°		0 42−	0 56+	0 14+	0 8+	0 6+	0 8+	0 15+
	180°		0 34+	0 11+	0 6+	0 5+	0 6+	0 11+	0 34+
	$\phi = 0°$		0 25−	0 7−	0 4−	0 3−	0 4−	0 7−	0 25−
D = 2,000 metres ...	35°		0 10−	0 5−	0 4−	0 5−	0 10−	0 52+	0 23+
a = + 36 metres ...	90°		0 10−	0 7−	0 9−	0 39+	0 9+	0 7+	0 10+
b = − 36 metres ...	135°		0 25−	0 52+	0 9−	0 5+	0 4+	0 5+	0 10+
	180°		0 23+	0 7+	0 4+	0 3+	0 4+	0 7+	0 23+
	$\phi = 0°$		0 19−	0 5−	0 3−	0 3−	0 3−	0 5−	0 19−
D = 2,500 metres ...	35°		0 9−	0 4−	0 3−	0 4−	0 4−	0 51+	0 18+
a = +	90°		0 9−	0 5−	0 7−	0 38+	0 8+	0 5+	0 8+
b = −	135°		0 19−	0 51+	0 8+	0 4+	0 3+	0 4+	0 8+
	180°		0 18+	0 5+	0 3+	0 3+	0 3+	0 5+	0 18+

The sign + or −, the interval, shows that during the interval the initial distance D has increased or diminished; ϕ shows the angle of the course of the ship which is firing with the bearing of the enemy's ship; θ, the angle of the courses taken by the two ships: D, the initial distance; a, the portion of the fire-angle behind the distance D; b, the portion of the fire-angle before the distance D. In other terms, a is the distance to which the object may stand away; d, is that to which it may approach, still being within range; on the figure 2 $a = BB''$ and $b = BB'$.

It may be seen by this table that in all cases of the reciprocal movement of ships, with the exception of the parallel course, the interval of time during which the object is within the fire-angle is generally small, and decreases rapidly as the distance of the object augments.

If you take 30 seconds as the duration of the pointing,[1] which is probably a much smaller figure than that of the real duration, it will

[1] According to observations made in the Russian artillery and foreign artillery, the duration of pointing is about 30 seconds for guns of 8 inches.

be seen that already, at the distance of three cables' length, no projectile will reach the object under certain positions of the adversaries, if, let it be understood, we presume the gun of 22 c.m. to be of perfect precision; that is to say, when at each shot, with the same sight, the projectile would follow identically the same trajectory. Besides, the greater the distance becomes, the more frequent will be the occasions in which the projectiles will not reach the object.

It is evident from all that has just been said that, with the exception of a small number of instances, no projectile hits the centre of the object when firing at a movable object, even when the gun has absolute precision, when the distance is measured with mathematical exactitude, and when the line of sight is directed with precision to the centre of the object.

Let us pass on now to the reality, that is to say, let us examine the influence of the variation in the distance of ships during the interval of pointing, when the shots deviate. Let us in the first place remark that the fire-angle, and in consequence the interval of time during which the object is exposed to the shots, is augmented.

Let us suppose in short that CA (Fig. 2) represents the height of the gun above the water, *bo*B the object, and C*b*′, OB″ the average trajectory drawn by the centre of the object O. Besides, C*ets*D′ and C*ds*′*t*′E′ represent the two extreme trajectories, that is to say, those which are the most lowered under or rise the most above the average trajectory. If there were no deviation in the height of the object equal to *b*B, all the shots would fall upon the object, if they fell in the interior of the square B′BB″, whilst in cases where the shots are dispersed between the two trajectories C*t*D′, C*d*E′, it suffices that they should fall on the interior of the space EBE′.

Nevertheless, there exists a difference between the fire-angle B′BB″ corresponding to the case of absolute precision, and the space EBE′ corresponding to that of deviation.

In the case of an absolute precision, the object is inevitably reached as long as it remains in the space B′BB″, whilst in the case of deviation the object can only be reached by every shot when it is within the space BBO′, limited by the vertical *d*D from the point of intersection of the superior trajectory with the horizontal drawn to the summit of the object, and by the vertical of the point of intersection D, of the trajectory with the horizon. As to the remaining parts DE and D′E′ of the total fire-angle, they present this peculiarity, that the object, when in one or other of these positions, may or may not be reached, according to the direction of the deviation of the trajectory, in reference to the mean trajectory. This difference between the space DBD′ and the spaces DE, D′E′ becomes much more evident if, instead of firing a single shot from a gun, a volley of a hundred similar shots are fired, for the hundred simultaneous trajectories will be all comprised within the inferior and superior limits. If at the moment of the broadside the object is within any point in the interior of DBD′, it will receive the hundred projectiles; if, on the contrary, it is within any of the points of one of the spaces DE, D′E′ it will receive only a part of the hundred projectiles. Besides which,

the number of projectiles that it will receive will be so much the less, because it will be nearer the extreme position $eEe'E'$.

Accordingly, it may be said that in the fictitious event of the absolute precision of the gun, all the fire-angle is a space that is sure to be reached, whilst in the actual case of the dispersion of the shots, the space that is certain to be reached will be reduced to DBD′; the other portion of the fire-angle DE and D′E′ will, on the contrary, only have a certain probability of being reached. It is seen on the drawing how, on account of the deviation and dispersion of the shots, and notwithstanding the augmentation of the total fire-angle EBE′, the space that is sure to be reached is diminished.

We may take approximately the arc of the trajectory ds' (Fig. 2) for a straight line, and the angle bds' for the angle of the fall. Designating therefore this angle by θ, we have $bd - \frac{bs'}{tg\theta}$. If, to simplify it, you take $BO' = bd$, we shall have $DBO'' = 2\frac{bs'}{tg\theta}$. Therefore, it is seen that $bS' = bO - S'O$; bO is the half height of the object, and S′O is the maximum deviation that may be replaced by four times the medium deviation. Calling h the height of the object and k the mean deviation, we have: $DBD' = \frac{h - 8k}{tg\theta}$.

Remarking that k diminishes when the precision increases and θ decreases when the chord of the trajectory increases, we see that the extent of the space DBD′ that is sure to be reached, increases for a same height of object, when the precision of the firing and the chord of the trajectory augment. As the precision of the firing diminishes, when the distance of the object increases, whilst the angle of the fall augments at the same time, there are two reasons that the extent of this space should diminish rapidly when the distance of the object becomes greater.

It is understood that at the distance for which $h = 8k$ and for superior distances, the space which is sure to be reached no longer exists, and that for a same height of the object h, the existence of this space depends entirely on the precision of the firing.

From all that has been said, it results that in firing whilst moving, on an immovable object, and pointing in the ordinary manner with the sight, three things may happen. If, at the end of pointing, the object does not leave the space that is sure to be reached, DBD′, the shot must necessarily reach it; if it is out of this space, but is still in a doubtful interval, it is to be hoped that a broadside will reach it, and this hope will be the more justifiable that the object will be nearer to B′B″. But if, at the moment of firing, it is out of the space EBE′, all the shots will be lost. It is unnecessary to say that when there is no distance which is sure to be reached, one can only rely on a lucky chance.

We have already seen that the time during which the immovable object or the enemy remains within the fire-angle depends: 1st, on the length of the fire-angle; 2ndly, on the speed of the adver-

TABLE II

Percentage of Hits in firing from a Ship in motion at another Ship in motion, supposing Distance exactly known, Pointing done in 30 se

Speed of each ship = 10 knots.
Guns of 22 centimetres, initial velocity 435 metres.
Length of enemy's ship, 100 metres; breadth, 18 metres; height out of water, 6 metres.

θ Angle between the ships' courses.
ϕ Angle between the ship's course and the bearing of the enemy.

Distance of Ships at first.	Least deviation of projectiles. Vertical.	Least deviation of projectiles. Horizontal.	Angle between course and the bearing of enemy.	For an angle between the courses, $\theta = 0°$. For 30 seconds. a.	i.	l.	p_v	p_h	Percentage of hits.	For an angle between the courses, $\theta = 45°$. For 30 seconds. a.	i.	l.	p_v	p_h	Percentage of hits.	For an angle between the courses, $\theta = 90°$. For 30 seconds. a.	i.	l.	p_v	p_h	Percentage of hits.	For an angle between the cour For 30 seconds. a.	i.	l.	p_v
	metres.	metres.		met.	deg.	met.				metres.	deg.	met.				metres.	deg.	met.				metres.	deg.	met.	
500 metres ...	1·11	1·11	ϕ = 0°	0	0	18	0·968	1·000	97 §	− 32	32	55	0·958	1·000	96 §	−121	66	92	0·805	1·000	81 §	−239	20	40	0·346
			45°	0	45	71	0·968	1·000	97 §	−107	83	100	0·845	1·000	85 §	−218	45	71	0·436	1·000	44	−239	25	47	0·346
			90°	0	90	100	0·968	1·000	97 §	−107	38	62	0·845	1·000	85 §	−121	24	46	0·805	1·000	81 §	− 29	79	99	0·961
			135°	0	45	71	0·968	1·000	97 §	− 31	16	34	0·958	1·000	96 §	+ 46	69	92	0·945	1·000	95 §	+156	66	92	0·689
			180°	0	0	18	0·968	1·000	97 §	+ 56	56	83	0·937	1·000	94 §	+172	77	98	0·629	1·000	63 §	+271	37	62	0·231
1,000 metres ...	2·92	2·88	ϕ = 0°	0	0	18	0·587	0·988	58 §	− 39	37	62	0·559	1·000	56 §	−140	80	89	0·315	1·000	32	−255	37	62	0·075
			45°	0	45	71	0·587	1·000	59 §	−108	87	100	0·405	1·000	41	−218	45	71	0·129	1·000	13	−255	8	25	0·075
			90°	0	90	100	0·587	1·000	59 §	−108	42	68	0·405	1·000	41	−140	10	27	0·315	1·000	32	− 71	61	88	0·499
			135°	0	45	71	0·587	1·000	59 §	− 39	7	24	0·559	1·000	56 §	+ 24	57	84	0·576	1·000	58 §	+140	77	98	0·315
			180°	0	0	18	0·587	0·988	58 §	+ 51	51	78	0·541	1·000	54 §	+164	82	100	0·251	1·000	25	+268	40	65	0·058
1,500 metres ...	·32	5·16	ϕ = 0°	0	0	18	0·349	0·834	28 §	− 41	41	66	0·331	1·000	33 §	−145	84	100	0·182	1·000	18	−253	50	77	0·047
			45°	0	45	71	0·349	1·000	35 §	−108	88	100	0·243	1·000	24	−218	45	71	0·081	0·036	8	−258	5	22	0·047
			90°	0	90	100	0·349	1·000	35 §	−108	43	69	0·243	1·000	24	−145	7	24	0·182	1·000	17	− 84	56	83	0·282
			135°	0	45	71	0·349	1·000	35 §	− 41	4	21	0·331	0·878	29 §	+ 16	53	80	0·346	1·000	35 §	+131	88	100	0·206
			180°	0	0	18	0·349	0·834	29 §	+ 48	49	76	0·326	1·000	33 §	+162	85	100	0·155	1·000	16	+267	41	66	0·041
2,000 metres ...	8·77	8·33	ϕ = 0°	0	0	18	0·212	0·612	13 §	− 42	42	71	0·203	1 000	20	−148	85	100	0·122	1·000	12	−260	49	76	0·039
			45°	0	45	71	0·212	1·000	21 §	−109	89	100	0·157	1·000	16	−218	45	71	0·065	0·708	7	−260	4	21	0·039
			90°	0	90	100	0·212	1·000	21 §	−109	44	70	0·157	1·000	16	−148	5	22	0·122	1·000	9	− 91	53	80	0·152
			135°	0	45	71	0·212	1·000	21 §	− 42	3	20	0·203	0·663	13	+ 12	51	78	0·210	1·000	21 §	+126	83	100	0·142
			180°	0	0	18	0·212	0·612	13 §	+ 48	48	74	0·200	1·000	20	+160	86	100	0·112	1·000	11	+266	42	68	0·066
2,500 metres ...	13·3	12·4	ϕ = 0°	0	0	18	0·146	0·438	6 §	− 43	42	71	0·140	0·980	14	−149	86	100	0·092	0·982	9	−261	48	75	0·036
			45°	0	45	71	0·146	0·982	14 §	−109	89	100	0·114	0·999	11	−218	45	71	0·054	0·430	5	−261	3	20	0·036
			90°	0	90	100	0·146	0·999	15 §	−109	44	70	0·114	0·975	11	−149	4	21	0·092	0·885	4	− 95	51	78	0·121
			135°	0	45	71	0·146	0·982	14 §	− 43	3	20	0·140	0·480	7	+ 10	50	77	0·145	1·000	14 §	+122	84	100	0·107
			180°	0	0	18	0·146	0·438	6 §	+ 48	47	73	0·139	0·982	14	+159	87	100	0·086	1·000	9	+266	43	70	0·033
3,000 metres ...	20·3	18·7	ϕ = 0°	0	0	18	0·090	0·297	3 §	− 43	43	68	0·087	0·855	7	−150	87	100	0·064	0·967	6	−261	47	74	0·032
			45°	0	45	71	0·090	0·736	7 §	−109	89	100	0·075	0·967	7	−218	45	71	0·044	0·736	3	−261	2	20	0·032
			90°	0	90	100	0·090	0·967	9 §	−109	44	70	0·075	0·866	6	−150	4	21	0·064	8·530	2	− 97	50	77	0·078
			135°	0	45	71	0·090	0·864	8 §	− 43	2	20	0·087	0·330	3	+ 8	49	76	0·090	0·896	8 §	+120	85	100	0·072
			180°	0	0	18	0·090	0·297	3 §	+ 47	47	73	0·087	0·881	8	+158	87	100	0·061	0·967	6	+265	43	70	0·031

Remarks.—The sign § after a number in the column of percentages shows that in 30 seconds the enemy does not leave the space covered by the least trajectory. Accordingly the p
as the accuracy of the gun increase

TABLE II.

done in 30 seconds, Line of Fire directed on Centre of Object, and the Sight being on the Groove which corresponds exactly with the Distance.

a Increase or decrease of distance in 30 seconds.
i Angle between vertical plane of enemy and direction of fire.

l Projection of length of enemy on a plane perpendicular to line of fire.
p_v Probability of hitting vertically. p_h Probability of hitting horizontally.

le between the courses, $\theta = 135°$.				For an angle from $\theta = 180°$.						For an angle from $\theta = +135°$.						For an angle from $\theta = +90°$.						For an angle from $\theta = +45°$.					
conds.	p_v	p_h	Percentage of hits.	For 30 seconds.			p_v	p_h	Percentage of hits.	For 30 seconds.			p_v	p_h	Percentage of hits.	For 30 seconds.			p_v	p_h	Percentage of hits.	For 30 seconds.			p_v	p_h	Percentage of hits.
l.				a.	i.	l.				a.	i.	l.				a.	i.	l.				a.	i.	l.			
met.				metres.	deg.	met.				metres.	deg.	met.				metres.	deg.	met.				metres.	deg.	met.			
40	0·346	1·000	35	−309	0	18	0·129	1·000	13	−239	20	40	0·346	1·000	35	−121	66	92	0·805	1·000	81 §	− 32	32	55	0·958	1·000	96 §
47	0·346	1·000	35	−144	83	100	0·736	1·000	74 §	− 29	56	83	0·961	1·000	96 §	+ 46	21	42	0·945	1·000	95 §	+ 56	11	28	0·937	1·000	94 §
99	0·961	1·000	96 §	+ 88	58	85	0·896	1·000	90 §	+156	21	42	0·689	1·000	69 §	+172	13	32	0·629	1·000	63 §	+110	49	76	0·835	1·000	84 §
92	0·689	1·000	69 §	+251	28	50	0·302	1·000	30	+271	8	25	0·231	1·000	23	+218	45	71	0·436	1·000	44	+110	86	100	0·835	1·000	84 §
62	0·231	1·000	23	+309	0	18	0·129	1·000	13	+271	37	62	0·231	1·000	23	−172	77	98	0·629	1·000	63 §	+ 56	56	83	0·937	1·000	94 §
62	0·075	1·000	8	−309	0	18	0·027	0·988	3	−235	37	62	0·075	1·000	8	−140	80	89	0·315	1·000	32	− 39	37	62	0·559	1·000	56 §
25	0·075	1·000	8	−188	61	88	0·191	1·000	19	− 71	74	96	0·499	1·000	50 §	+ 24	33	56	0·576	1·000	58 §	+ 51	6	24	0·541	1·000	54
88	0·499	1·000	50 §	+ 46	73	96	0·554	1·000	55 §	+140	32	56	0·315	1·000	32	+164	8	30	0·251	1·000	25	+110	47	74	0·402	1·000	40
98	0·315	1·000	32	+238	35	59	0·095	1·000	10	+268	• 4	21	0·058	0·994	6	+218	45	71	0·129	1·000	13	+110	88	100	0·402	1·000	40
65	0·058	1·000	6	+309	0	18	0·027	0·988	3	+268	40	65	0·058	1·000	6	+164	82	100	0·251	1·000	25	+ 51	51	78	0·541	1·000	54
77	0·047	1·000	5	−309	0	18	0·020	0·834	2	−258	50	77	0·047	1·000	5	−145	84	100	0·182	1·000	18	− 41	41	66	0·331	1·000	33 §
22	0·047	0·910	4	−200	55	82	0·103	1·000	10	− 84	79	98	0·282	1·000	28	+ 16	37	60	0·346	1·000	35 §	+ 48	4	20	0·326	0·878	29 §
83	0·282	1·000	28	+ 31	78	98	0·338	1·000	34 §	+131	36	60	0·206	1·000	21	+162	5	22	0·155	0·911	14	+110	47	74	0·230	1·000	23
100	0·206	1·000	21	+232	39	63	0·068	1·000	7	+267	4	21	0·041	0·878	4	+218	45	71	0·081	1·000	8	+110	88	100	0·230	1·000	23
66	0·041	1·000	4	+309	0	18	0·020	0·834	2	+267	41	66	0·041	1·000	4	+162	85	100	0·155	1·000	15	+ 48	49	76	0·326	1·000	33 §
76	0·039	1·000	4	−309	0	18	0·020	0·612	1	−260	49	76	0·039	1·000	4	−148	85	100	0·122	1·000	12	− 42	42	67	0·203	1·000	20
21	0·039	0·708	3	−205	52	80	0·073	1·000	7	− 91	82	100	0·152	1·000	15	+ 12	39	64	0·210	0·998	21 §	+ 48	3	20	0·200	0·664	13
80	0·152	1·000	15	+ 24	81	99	0·209	1·000	21 §	+126	38	62	0·142	0·997	14	+160	4	21	0·112	0·663	7	+110	46	72	0·156	1·000	16
100	0·142	1·000	14	+229	30	64	0·507	0·988	6	+266	3	20	0·036	0·663	2	+218	45	71	0·065	1·000	7	+110	89	100	0·156	1·000	16
68	0·066	1·000	4	+309	0	18	0·020	0·612	1	+266	42	68	0·036	1·000	4	+160	86	100	0·112	1·000	11	+ 48	48	74	0·200	1·000	20
75	0·036	0·984	4	−309	0	18	0·020	0·438	1	−261	48	75	0·036	0·984	4	−149	86	100	0·092	1·000	9	− 43	42	68	0·140	0·980	—
20	0·036	0·480	2	−208	50	77	0·059	0·985	6	− 95	84	100	0·121	0·999	12	+ 10	40	66	0·145	0·966	14 §	+ 48	2	20	0·139	0·480	—
78	0·121	0·988	12	+ 19	83	100	0·144	0·999	14 §	+122	39	63	0·107	0·954	10	+159	3	20	0·086	0·480	4	+110	46	72	0·114	—	—
100	0·107	0·999	11	+227	40	65	0·050	0·960	5	+266	2	20	0·033	0·480	2	+218	45	71	0·054	0·980	5	+110	89	100	0·114	—	—
70	0·033	0·975	3	+309	0	18	0·020	0·438	1	+266	43	70	0·033	0·975	3	+159	87	100	0·086	1·000	9	+ 48	47	73	0·139	—	—
74	0·032	0·887	3	−309	0	88	0·020	0·297	1	−261	47	74	0·032	0·887	3	−150	87	100	0·064	0·967	6	− 43	43	68	0·087	—	—
20	0·032	0·329	1	−210	49	76	0·046	0·896	4	− 97	85	100	0·078	0·967	8	+ 8	41	66	0·090	0·842	8 §	+ 47	2	20	0·087	—	—
77	0·078	0·896	7	+ 16	84	100	0·080	0·967	9 §	+120	40	65	0·072	0·827	6	+158	3	20	0·061	0·330	2	+110	46	72	0·075	—	—
100	0·072	0·967	7	+226	41	66	0·041	0·840	3	+265	2	20	0·031	0·330	1	+218	45	71	0·044	0·864	4	+110	89	100	0·075	—	—
70	0·031	0·866	3	+309	0	18	0·020	0·297	1	+265	43	70	0·031	0·866	3	+158	87	100	0·061	0·967	6	+ 47	47	73	0·087	—	—

ccordingly the percentages affected by the sign § increase with the accuracy of the gun, and approach 100 per cent., whilst the percentages adversely affected by the sign § diminish the gun increases, and approach zero.

saries; 3rdly, on the position of their course with reference to direction of firing. Besides, it has just been explained that the number of projectiles which strike the object depends on the distance between the positions occupied by it at the moment of firing and the moment when the sight was adjusted. It is then seen that the number of projectiles depends upon numerous circumstances. To be able to judge a little correctly, what would be the success in a battle in firing with a sight, it is necessary at least to have approximate numbers to determine the percentage of shots which fall upon a vertical object at given dimensions; it is necessary to know the mean deviations in a horizontal and vertical sense. The deviations indicated in the tables of firing cannot be of use here, because they represent a dispersion which results solely from the want of precision of the guns, the projectiles and powder which have not sustained any adulteration. In the firing *à bord*, this dispersion is increased by many new causes which did not exist in the firing of which the results have been used to establish the tables.

To know the percentage of the shots which take effect in an ordinary combat with a sight, the Table II, also made by M. Lucca for a gun of 22 c.m. of the artillery of the Italian Navy, may be consulted. This author explains that to calculate the number of shots reaching this object, he has taken the mean deviations, not such as they are in the tables, but such as they have been proved to be by circumstantial observations in firing *à bord*, in order to show forth the influence exercised on the precision of firing under all the circumstances of firing at sea. These deviations indicated in the table differ considerably from the deviations shown in tables for the firing of our guns. It must be remarked that these deviations have been deduced from firing at sea with a sight in the ordinary manner; that is to say, that the sight and the deviations seen in the tables were given by means of some rapid and searching experiments directed by the pointer; therefore, they represent the true precision of practical firing with a sight with the present customs.

To determine the percentage of shots reaching the object, such as results from the table, it is admitted that the percentage does not depend upon the length CD of the ship (Fig. 1), but upon the projection cd of this length upon the perpendicular plane in the direction of the firing AB; so that if by i the angle of the two directions AB and BC is shown, we shall have cd = CB sine i. Thus, according as the position of the ship varies with respect to the direction of the firing, this length will itself vary, its minimum value is equal to the breadth of the ship.

We must make the following remarks upon the figures of Table II:—

1stly. These figures are calculated upon the following data:—A speed of 10 knots for the two ships; a duration of pointing of 30 seconds; length of the ship, 100 metres; the breadth of the ship, 18 metres; and the height 6 metres. Other data can evidently be taken without departing from the conditions which are really met with in the practice. If the speed of the ship and the duration of pointing are augmented, and if the dimensions of the ship are diminished, the

effect will be to reduce the value of the figures of the table. The figures of the table then may be considered as a maximum of the percentage that may be obtained in the practice, by following the usual rules of firing with a sight.

2ndly. The accompanying figures of the sign § give the diminished percentage of the dispersion of the shots; that is why these figures increase with the precision of the gun; for an absolute precision of the gun would give cent. per cent.; the figures not affected by the sign § represent, on the contrary, the shots which reach by reason of the dispersion; so that they diminish when the precision of the firing increases, and become nil when the latter is infinite. In other terms, the figures not affected by the sign § refer to the case when the object is found at the moment of firing in one of the spaces EB′ or E′B″ (Fig. 2), and the figures affected by the sign § correspond to the case when the object is found between B′ and B″ at the moment of firing. As no percentage is found in the table, the result is, that for the gun and mean deviations in question there is no space which is sure of being reached, such as D′D″; in other terms, the duration of pointing is so great, that at the moment of firing the ship is already out of the space.

To facilitate the reading of the comparison of the figures of this table, the relative position of the ships A and B, for which these figures have been calculated, have been graphically represented upon the Figure 6. A represents the ship which is firing; B, the object; AB, the direction of the firing. The figures placed round the ship B indicate the percentage of the shots which ought to reach it. The numbers placed between the first and second circle described from the centre B correspond to the distance of 500 metres. The numbers placed outside of the second circle refer to the distance of 1,000 metres. The following conclusions may be drawn from the comparative study of these figures:—

1. The percentage of the shots which reach the object depends in a great measure upon the relative position of the ships at the moment of firing; in general, it is maximum when the two ships sail in a parallel line.

2. For a same relative position of the vessels, this percentage decreases rapidly when the distance augments.

3. By beginning at a distance of 500 metres (the shortest which is indicated on the table), there is no certainty of reaching any particular space.

Table II shows clearly that already, at a distance of 500 metres from the object, it is not possible to be certain of hitting the object with every shot. At that distance, as at all others, there is only a probability, more or less great, of reaching the object. This probability, although even not great, serves above all in practice, where the only important thing is to know whether a projectile will reach or not, to calculate the number of projectiles which must be sent in a given case, in order that a certain number may reach the object. For example, in all cases where the percentage indicated is less than a hundred and greater than fifty, two shots must successively or simultaneously be

fired, in order that one of them may inevitably reach. In general, in all these cases, if all the guns of a battery are fired, half only will take effect. Minute observations made in the Station Fleet have shown that while moving, two guns out of five only can be fired, *i.e.*, have sights on at the instant of firing (*under favourable circumstances*). In consequence, one is authorized to believe that a ship having five guns on a side, in all cases where the Table II indicates a percentage of shots comprised between a hundred and fifty, can only reckon upon one certain shot. It must be understood that this only has reference to those cases where the movement and dimensions of the ships are the same as what has been supposed for the calculation of the Table II.

It must be added, nevertheless, that in the calculation of this Table II it is admitted that the object presents a surface geometrically plane, having no projection in the direction of the firing, whilst in reality, in all the possible positions of the ship, it has a projection in that direction. If we take this projection into consideration, the number of shots which reach the object will be increased. This may be easily seen on Fig. 3, which represents firing upon a ship which is advancing in the direction of the shot. In this case, in order that no projectile should reach, the taffrail must be out of the fire-angle, that is to say, that the ship must be in the position indicated by a straight line. If she is in such a position as that the superior summit of the stern-post, *e*, shall alone be out of the fire-angle, then, although none of the shots may reach the body of the ship, they may fall upon the deck in the interior of the vessel, the whole or part of the shots, according as the projection of the object in the direction of the shots is equal or superior to the value *ed* of the double of the mean deviation in the range. As it is usual to aim upon the surface of the ship turned towards the point from which is the firing, it is expedient to add to the space of the fire-angle, EE′, determined for the case in which the object is supposed to have a plane surface, the extent of the ship in the direction of the firing, but only from the side on which is the firing.

This extent, equal to the length of the projection of the ship in the direction of the firing, will evidently vary with the position of the object, the maximum will be equal to the length of the ship, the minimum to her breadth. So that if account is taken of all the shots, whether they strike the side or fall upon the deck, all the fire-angle is divided by the point, D, in two unequal parts, DF and DF′, and in consequence the ship will be exposed much longer to the firing when she approaches the enemy than when she stands away from it.

We have supposed up to the present that the shot goes off when the line of sight passes precisely across the centre of the object, but in reality it cannot be so. With the construction of the apparatus for actual pointing, which is always fixed upon the gun carriage, the chief gunner gives the command "fire!" at the moment when the line of sight passes the centre of the object, but he can only fire when the artilleryman has withdrawn his hand from the apparatus for pointing, in consequence of which, between the moment that the line of sight reaches the position required and the gun is fired, an interval of time more or less great, which is not to be neglected, must always elapse.

During this time, that we will call the "interval of fire," the line of sight moves away from the centre of the object in a horizontal direction, caused by the moving of the two ships; even if we suppose the guns to have absolute precision, the shot will no longer fall on the centre of the object. Let us suppose, in short, that at the moment of the "order to fire" the ships occupy the positions a and b (Fig. 4), and that the direction of the firing should be the line ab; if during the "interval of fire" the first ship has come in a' and the second in b', the line of firing will be at the moment of firing the line $a'b''$ parallel to ab, and the shot will strike at a distance $b'b''$ to the left of the centre of the object. This deviation does not exist when the two ships advance upon the line of firing or follow parallel courses with the same speed. It reaches, on the contrary, its greatest value for the given speed of the two ships when they follow an inverse and perpendicular course to the line of firing. It is clear that on account of the "interval of fire" the shot never strikes the centre of the object, but deviates in a horizontal direction towards the side of the course of the ship which is firing if the two courses are on one side, and on the other of the line of firing on the converse side. On the contrary, if the two courses be on the same side of the line of firing, the projection of the speed of the object upon a line $c'n$, perpendicular to the line of firing, is greater than the projection of the speed of the other ship upon this same line.

Besides, if the projection $c'c$ of $b'bb''$ on this line is greater than half the length, mn, that is to say, than the half of the projection of the length of the ship upon this line $c'n$, the shot will not reach the object. It results from this that in a perpendicular direction to the line of sight the fire-angle is equal to the projection of the length of the ship in this direction. It is understood that for a given speed and a given course of the two engaged ships and on same length of object, the length of the deviation $c'c$ is proportional to the "interval of fire." It is also seen that, on account of the existence of this interval, not a single shot, even from a perfectly precise gun, will reach the centre of the object, if this last is moving with a relative speed, however small it may be, perpendicular to the plane of firing. On the other side it is known that the shots have also a dispersion in a horizontal sense, and this dispersion modifies the action exercised by the "interval "of fire" on the number of good shots. Supposing $a'o'$ (Fig. 5) the horizontal projection of the mean trajectory, $a'b$ and $a'e$ the projections of the extreme trajectories, so that be represents the double of the lateral maximum deviation. Let us suppose besides that the object moves perpendicularly to the direction ao of the firing, and that the point o represents the position of the centre of the object at the moment of the command "fire." As long as the relative displacing $o'oo''$ of the object during the "interval of fire" is less than the difference $o''b - o'b$ between the half length of the object $o''b$, and the maximum horizontal deviation $o'b$, all the shots will reach. If, on the contrary, the relative displacing of the object is greater than the sums of these two quantities, none of the shots will reach. For all the magnitude of the relative displacement of the object comprised between these

two limits, a part only of the shots will reach the object. For the same length of object, the same relative speed, and the same interval of the "toos," the influence of this last element will increase with the distance of the object, because the lateral deviations increase themselves with this distance.

If we take the case in which the "interval of fire" has the least influence, namely, when the relative speed of the object is a speed of 20 knots, perpendicular to the line of firing, then, in order that no shot should miss (the dimension of the object and the horizontal deviation being those indicated in Table II), the "interval of "fire" ought to be less than 4·4 or 3·7, or 2·8 or 1·6, to the different distances given in the table. At the greater distances of $13\frac{1}{2}$ cable lengths there is no longer any space in which the shots are sure to take effect. If it is admitted that the "interval of fire" cannot be less than a second, the space that is sure to be reached in a horizontal direction is 12 cable lengths.

It remains to be added that the time during which the vessel will be in the transversal space which is sure to be reached, will diminish, other things being the same, with the length of the ship.

The number of shots pointed with the sight upon ships (with broadside battery) which reach the object is very sensibly diminished by the important circumstance which follows: Table II shows that the greatest percentage of good shots is obtained when the enemy advances abreast, and in an opposite direction. But in a ship with broadside battery, firing in this advantageous position is often impossible, because to fire in this position the distance must be measured almost at the moment in which the adversary enters into the field of the horizontal firing of the guns, and to endeavour to fire before it leaves this sector. Furthermore, if for a given course of the combatants, the time during which the adversary is within the range of the firing of the gun is greater than the time necessary for the pointing, then the firing is possible; on the contrary, the firing is impossible when, before the line of sight is brought to bear upon the centre of the object, the adversary is out of the horizontal sector of the firing of the gun. Table III indicates under what circumstances the firing is possible or impossible, for it gives the time during which the adversary remains in the sector of firing for several different positions of the ships engaged, supposed to be animated with a speed of 10 knots. In this table the sector of firing is made equal to 40°, consequently greater than that which is in use at the present time in ironclads.

TABLE III.

Time that an object moving with speed = 10 knots takes to cross a sector of 40° from a gun in a ship moving with same speed.

Distance D.	Opposite courses approaching at		Opposite courses separating at		Courses parallel and reverse, $\theta = 180°$.
	Angle $\theta =$ 135°.	Angle $\theta =$ 157° 30′.	Angle $\theta =$ 157° 30′.	Angle $\theta =$ 135°.	
metres.	m. s.	m. s.	m. s.	m. s.	m. s.
100	0 7	0 6	0 8	0 9	0 7
200	0 14	0 13	0 15	0 18	0 13
300	0 20	0 19	0 23	0 28	0 20
400	0 27	0 26	0 30	0 37	0 27
500	0 34	0 32	0 38	0 46	0 34
600	0 41	0 38	0 45	0 55	0 40
700	0 48	0 45	0 53	1 4	0 47
800	0 54	0 51	1 0	1 14	0 54
900	1 1	0 58	1 8	1 23	1 0
1,000	1 8	1 4	1 15	1 32	1 7

We have already remarked that the adversary may be kept within the range of firing as long as necessary by making use of the rudder, but it is necessary for this that helmsmen should follow the position of this ship in the sector, which has not yet been done in successive firing, and we cannot say how far that may be possible.

If we presume that the sea is calm, that the ship which fires has an apparatus which permits of measuring the distance rapidly and exactly, then the pointing will be well done and the line of sight will be precisely directed upon the given point, but from all that has already been said about firing executed in using the ordinary sight and the usual rules, the result is that:

1st. In the distances greater than $3\frac{1}{2}$ or 4 cable lengths and in successive firing, one can never reckon more than a single shot reaching.

2nd. If the enemy is not kept by means of the rudder in the horizontal sector of firing, the firing by means of the sight becomes impossible at short distances, because at these distances the enemy's ship is too rapidly out of the range of firing.

3rd. In firing upon an object which moves with great rapidity every chief gunner ought, before perceiving the point upon which he wishes to bring the line of sight, previously direct the gun upon the point where he supposes the point to be aimed at is going to pass, otherwise he could not point. This preparation on the contrary accelerates the pointing.

4th. The inconvenience of this pointing prepared in advance is that it cannot be simultaneously applied to all the guns of a battery; and consequently renders impossible the instantaneous firing of the broadside.

It is clear then in consequence that in battle the firing ought to be performed by the aid of a system of preparation pointing. Let us see then what this system ought to be.

But before we pass on to the study of this system, it is necessary to fill up a gap which we have allowed to subsist when treating on successive firing. All that we have said has reference to an entirely regular displacement of the ship which is firing without any oscillation, or, in other terms, without taking count of the rolling. But it is not so in reality. All steamers roll a little, even in a very calm sea. By reason of these oscillations during the "interval of fire," the line of sight has deviated in the vertical plan, either up or down, so that the angle of firing is increased or diminished, and a new deviation is the result. If we suppose that during the pointing and the "interval "of fire" the distance of the two ships does not vary, and that the precision of the gun is perfect, in order that shot may reach the object, the rolling must not displace during that time the line of sight at the distance of the object, by an equal height to the half height of this object. The corresponding angle naturally decreases in proportion as the distance augments. Thus the fact of reaching or missing an object of given dimensions at a given distance will depend upon the duration of the "interval of fire" and the rapidity of the rolling.

This "interval of fire," inevitable with the present construction of the mechanism of pointing, is then the principal cause of the great dispersion of shots fired by a ship in motion. A rolling with rapid oscillations at the moment of firing occasions considerable deviations.

System of Preparation for Pointing.

Until now there has been no other system of preparation for pointing but that of convergent firing; this is the method which was employed in the old wooden ships, and which is still employed on ironclads.

The point on which the line of sight is directed of all the guns of the battery ought evidently to be in the sector of the firing of all the guns. Several might evidently be chosen, but in what direction and at what distance ought the points of concentration centre be fixed? There are no absolute rules for this. The direction and the distance corresponding to each direction may be, so to say, arbitrarily chosen; various combinations have also been imagined for the installation of the system of preparing convergent firing.

Among these combinations the first place is accorded to that which, giving the fewest points of convergence, allows the installation to be simplified, and, which is more important still, diminishes the causes of confusion in firing in action.

With us up to now it has been agreed to distribute the points of convergence in three directions; abreast and by two extreme directions, one the most possible before, the other abaft the beam. There is no reason for choosing intermediate directions, because in general in ironclads with batteries the field of firing is not great, and besides it is always possible to command a given direction upon an enemy already placed in the field of firing; for this it is only necessary to use the

rudder. Table II shows that the greatest percentage of good shots are obtained when the enemy is abreast or nearly abreast of the ship which is firing; one direction alone, that of abreast, would then be sufficient; but as, on the other hand, the shock of the projectile produces its maximum effect under normal incidence, it is not superfluous to have also the two extreme directions. Thus, when two ships meet (see Fig. 7), the most advantageous direction for a normal firing, if they occupy the position 2, is that of the extreme before the beam at the moment the enemy enters the field of firing; if, on the contrary, they occupy the position 3, it is the direction of the extreme abaft the beam, when the enemy is leaving the field of firing. In case of need the rudder may be used.

We must remark besides that, although possessing the two extreme directions, nothing hinders us from using the direction on the beam.

The choice of a point on a given direction wants very little precision. The inferior limit of the distance on each direction is naturally determined; it is the distance at which the lines of sight are intersected by the extreme guns of the battery, when the after one is pointed as much as possible ahead, and the foremost one pointed as much as possible towards the stern. All the other distances are arbitrarily chosen, only taking into consideration the precision, that is to say, 1 per cent. Up to the present time the greatest distance of convergence has not with us been more than six cable lengths, and all the points taken on each direction were divided at equal distances between the two limits. Besides, it is impossible to expect that the object should be always on one of the points of convergence, and when it is found between two of these points, use the line of sight conducting to the nearest or the farthest of the two, but then the object at points as much farther from the other as the object itself is farther from the point to which this line of sight corresponds. In other words, every time that the object is not under one of the points of convergence, the lines of sight, and in consequence the shots fired, take a horizontal dispersion. However, no matter at what distance the object is from the point of convergence, the distance between the extreme lines of sight measured on the object can never be greater than the length AB from the battery (see Fig. 8).

It may be seen on Fig. 8, that if the object is at the distance HO, in the middle between two neighbouring points of convergence, the range of the lines of sight will be made exactly on the same length, whether directed upon C or upon C′. It is seen by this that the object being at the point C and C′, for distances less than HO, it will be more advantageous to direct the line upon the point C′; if, on the contrary, the distance is greater than HO, it will be more advantageous to take the point of convergence in C. Nevertheless, in adopting this mode of convergence, an object being within such a distance HO will be reached by all the shots, only in the case where *ab* is shorter than the length *mn* from the object, that is to say, when the range *cd* from the lines of sight, augmented to double the horizontal maximum deviation, will be smaller than this length *mn*.[1]

[1] On the figure 8 AF and BF represented the shots having the greatest deviation

From this results the manner in which the distance between two neighbouring points focus; it ought to be such that the length *cd*, augmented to double of the maximum deviation, is less than the length of the object taken perpendicularly to the line of firing.

It is in this manner that the point of convergence must be chosen, if the only object is to make the greatest number of shots reach the mark. But the question completely changes, when the destructive effect of the projectiles is to be considered. Let us suppose that in a broadside fired by the two guns A and B, the projectile shot by A describes the trajectory AG, which corresponds with the greatest deviation to the right, and the projectile shot by B the trajectory BF, which corresponds to the greatest deviation to the left, then the projectiles will meet at the point O, provided that their swiftness is equal to that point; if the object is somewhere between O and C, the projectiles will break each other, or will deviate reciprocally. In the first case they will not cause any harm to the enemy, and in the second it is impossible to know what will happen. And this meeting of the projectiles will not happen only in the case where the projectiles describe extreme trajectories on both sides. This meeting will be produced every time that the horizontal deviation will be in an inverse ratio, provided that the vertical deviation is equal and in the same ratio. To avoid this re-encounter of the projectiles fired by a broadside it is necessary to separate the lines of sight and not make them converge upon the centre of the object. The separation may be effected in a vertical or in a horizontal sense, or generally in some other direction, but as the height of the object is almost always less than its length, it must be effected in a horizontal sense. Besides, if the distance *cd* (on the object) of the two neighbouring lines, A*c* and D*d*, is equal to double the greatest horizontal deviation, the re-encounter of the projectiles will become impossible. If this distance is less, the re-encounter is again possible, and it is so much the more possible as the distance is shorter. It is seen by this that the proper distance of the broadside when the number of the guns of the battery augments, for this distance ought to be such that the difference of the extreme lines augmented to double the maximum deviation, should not be greater than the length of the object. Let us remark that with a like construction of the apparatus the lines of sight will become parallel when the double of the maximum deviation is equal to the distance of two neighbouring guns. That is why the apparatus in position cannot be designated by the name of convergent.

Experiments made in Germany (at Dulmer) have shown that a broadside of four guns, when the lines of sight are placed at the requisite distance, produce a destructive effect incomparably greater than that of four successive shots. However, it must be remarked that in these experiments the distance to the wall was only two cable lengths and the corresponding distance of the line 1 m. and 50 m.; therefore as this distance must be augmented with the remoteness of the object to prevent the projectiles meeting before they reach it, per-

to the left, and AC and BC those which have the greatest deviation to the right, when the lines of sight, AC and BC, of the extreme guns, AB, converge in C.

haps the broadside of a same number of guns of equal calibre would not produce the same destructive effect.[1] Besides, in the experiments at Dulmer, the four shots were grouped at the height of a square, whilst the lines of sight of the ships can only be dispersed on a horizontal line and not at all in elevation.

Let us examine now how the guns ought to be placed in a vertical sense. When the distance to the object is exactly known, it is evident that you must give the guns the exact elevation which corresponds to that distance, even though it should not be the same as that which corresponds to the point of convergence. And this is what is usually done. However, as the angle of elevation must be given to all the guns, even when the object is not in sight, there is room for inquiry as to how it can be done. If we suppose that the ship has not the slightest oscillation the ordinary sight might be used; it will suffice to put the sight at the requisite division and to point all the guns upon the line of the horizon.

In reality, a ship in motion, even in a calm sea, has always some oscillations, but they do not prevent all the guns from being laid at the same elevation. It is true that the smallness of the vertical dimension of the object requires that the pointing in height should be given with the greatest precision.

The pointing in height is usually done by the aid of a graduation, which, on board of our ships,[2] is engraved on metallic arcs fixed for that purpose against the gun carriage. The graduation of these arcs requires particular precision.

Thus, in convergent pointing, the guns are brought to the desired position in a vertical and horizontal sense by the aid of graduations placed in the interior of the ship, and which has given it the name of interior pointing. Under these conditions the precision of the firing depends, in the first place, on the precision of the graduation, and, in the second place, on the care with which the gunner brings the gun to the division indicated. Formerly, before the last experiment of converging firing made on our fleet, especially with the wooden carriages, the disposition of the graduation, as well on deck as in a vertical sense, could not be sufficiently exact. Besides which, with the play which existed in all parts of the system, especially under the trunnions, everything was incessantly vacillating, and the most expert chief gunner could not, notwithstanding all his efforts, keep the gun in the proper position. These minor details constituted one of the principal causes of the dispersion of the lines of sight and in consequence the dispersion of the shots.

With iron gun carriages, the parts of which are carefully made, convergent pointing may, at the present time, be effected in our ships with sufficient exactitude in practice, the more so as very precise apparatuses are employed. The exact and rapid adjusting of the guns

[1] We have already remarked that the French Commission on Ironclads had obtained a series of results at Gavre decidedly contradictory to the result of the isolated experiment at Dulmer.

[2] It must not be forgotten that we are speaking here of Russian guns.

to the desired point has been greatly facilitated latterly by the introduction of mechanical means for pointing or elevating.

At any rate, when the guns are placed exactly in a vertical or horizontal sense, there remains still this important question to resolve:—How to determine, if the point of convergence coincides with the centre of the object, that is to say, with the point on which the lines of sight must be directed. When the ship does not roll and does not move, and the object is at a distance exactly equal to that of the point of convergence, the coincidence with the centre of the object is determined by means of the indicator. On the circle of the indicator and through its centre three lines are drawn, the prolongations of which pass by the corresponding points of convergence. In consequence when the needle of the indicator (on the line of which the centre of the object must always be kept) passes by that of the three lines designated means that the centre of the object coincides with the point of convergence, that is to say, that the trajectory of the projectiles of all the guns will pass by the centre of the object.

When the ship lies along the point of convergence she is no longer at the same height above the horizon as that of the preceding case; the result is that if the object is at the exact distance and if the needle of the indicator always kept upon the centre of the object coincides with the direction marked out, it only means that at this moment the object is on the vertical of the point of convergence. To heighten or lower this last point to the coincidence of the centre of the object, the elevation of the axes of the guns must be corrected from the angle of laying; this angle of laying must therefore be known with great exactitude, since any error upon this angle would bring about an error in the elevation of the guns. This angle of laying was formerly determined by means of the indicator. For this a perpendicular direction to the diametral plan must be settled upon the *target* of the indicator, and going from this line as zero, the divisions of the graduation of the angle of the laying were brought on the target. If the horizon, then, was aimed at, the number of divisions comprised between the line of zero and the line by which passes the radius parallel to the horizon, gave the angle of laying. Without insisting that the aim of the horizon is not possible near the shore, let us remark that even when the horizon is visible the value of the laying thus determined will be erroneous if the line of zero traced on the target of the needle of the indicator is not perfectly perpendicular to the diametral plan. With the means of the establishment of the circle of the indicator, and its diametral plan which was then employed, the error in the position of the mediator could reach 1·2°. Therefore if, for example, a gun of 9 inches is fired with a charge of 52 lbs., and a distance of a cable length, supposing the line of sight directed on the centre of an object of 5 metres 5 centimetres in height, an error of 27′ in the inclination of the gun will suffice to make the mean trajectory deviate to such a height that not one of the shots will reach the object.

If we suppose that the vessel which is firing and the object are both stopped, and that their distance is precisely equal to that of the point

of convergence, then the oscillations of the first ship will cause the oscillations of the point of convergence, and at each of them there will be a moment in which it will coincide with the centre of the object. And this coincidence will be independent of the amplitude of the oscillations, as well as of the existence or absence of laying. Let us remark besides that an interval of two successive coincidences will be equal to the duration of an oscillation. Thus, by the rolling, whether much or little, the broadside should not be fired until the precise moment of the coincidence, without which the mean trajectory does not pass over the centre of the object, and the shots consequently deviate more or less. Therefore, when there is any rolling it is important to determine very exactly the coincidence of the point of convergence with the centre of the object. For this the indicator was still used. After having traced the perpendicular line to the diametral plan, the moment of the coincidence of this with the line of the horizon was observed, or otherwise (if the horizon was hidden by the object or by any other obstacle) with the line of the object which was supposed to be at the same level as the indicator. But on account of the defects in the establishment of the diametral plan on the circle of the indicator, it is evident that the moment of the coincidence was badly defined, and was the cause of important errors.

In summing up what precedes, it may be seen that therefore the direction of the gun in a vertical or horizontal sense, as well as the means of determining the moment of the coincidence between the centre of the object and the point of convergence, was surrounded by so many errors that the object could only be reached at very short distances; for long distances, even when the distance of the object was quite equal to that of the point of convergence, the number of shots reaching the object was insignificant.

If we take into account all the deviations which were produced in the ancient convergent firing by divers causes, namely, inexactitude of the direction of the gun, as much in a vertical as in a horizontal sense, given by the means of interior pointing; error in the determination of the moment of firing; error in the appreciation of the distance of the object: it may be easily understood that even not long ago ordinary firing was preferred to convergent firing.

Experiments executed by our fleet during the last few years show that in correcting convergent pointing of the above-mentioned faults the firing attains a great precision, and the distance at which a convergent broadside possesses a given precision is not less than the distance for which a shot pointed with the sight has the same exactitude.[1]

Without entering into details, we will endeavour to show sum-

[1] This result is obtained in firing at distances measured with exactitude and without rolling. That is why, taking into consideration the inevitable deviation of the line of sight of the ordinary sight, on account of the "interval of fire" and of rolling deviation which has been spoken of above, it appears evident that firing at measured distances and with rolling the percentage of good shots obtainable would be determined.

marily how the above-mentioned faults have been made to disappear from convergent pointing.

As far as regards the exactitude of the installation of the gun in relation to the divisions disposed in the interior of the ship, we have succeeded, as has already been stated, by the annihilation of play in the axes of rotation, the transport of the directions on the metallic arcs, and principally by the employment of very precise particular apparatus for the exact determination of the direction of the axis of the gun by the aid of vertical divisions.

The most characteristic feature of the new system of convergent firing consists in a particular apparatus for the determination of the instant of coincidence of the point of convergence with the centre of the object, and to assure the sending of the shot just at that instant. In this apparatus we will distinguish three parts—1st, electric firing; 2ndly, the indicator; and 3rdly, the krenometer.[1]

In this firing the loading is fired by the aid of electric quick matches introduced in the current of a pile. This current remains open until the moment of firing; then it is shut; the quick matches go off and set fire to the charge. It is the *ensemble* of the pile of the conductor and of the quick match that we call the electric flame (*inflammateur*).

The shutting of the current of this *inflammateur* is obtained with the help of the indicator and of the krenometer, which are introduced in the current.

The indicator is connected by conductors to the *inflammateur;* these conductors, which are usually separated, are only reunited when the needle of the indicator is upon the line of the indicator, the prolongation of which passes by the point of convergence, and which we will call line of aim. However, in order that at this instant the wires of the indicator should be reunited, it is necessary beforehand to place the bolt of the conjonctor upon that line.

The krenometer is also connected with the *inflammateur* by conducting wires; these wires, like those of the indicator, remain disunited until the krenometer marks the position previously shown of the diametral plan in reference to the horizon.

From this summary description of the working of the apparatus in question, it clearly shows that the indicator only marks if the object is in the direction of the designated convergence, and that independently of the krenometer, because the establishment of the circle of the indicator, as far as the diametral plan is concerned, is quite independent of the inclination of the gun. The question of knowing if the axes of the guns give the desired angle with the horizon, is resolved by means of the krenometer, which is used as well for small or great oscillations, for the normal position of the ship as well as for the rolling. By this it is seen, amongst other things, that the exact direction of the guns in a vertical sense, and in consequence the vertical dispersion of the shots for a given distance from the object, depends entirely upon the correctness of the indications of the krenometer.

A series of complete experiments have been made in Russia to deter-

[1] Apparatus to measure the *band;* from the Russian *krène,* band.

mine the extent of the exactitude of the indications of this instrument of peculiar construction.

If the immense number of causes which influence the devastation of shots in firing broadside is thought of, we can understand what an amount of observation and perseverance is necessary to remove, or at any rate to reduce, each of these causes to a minimum influence. If these divers influences are not removed, it would not be possible to form a sufficiently precise estimation of the extent of the exactitude of the indications of the krenometer, for the errors due to this instrument would be, if they existed, hidden by the deviations due to other causes.

It is well to remark here, that the results of the series of experiments undertaken to study the exactitude of the new krenometer, have had another import, which, although accessory, is not of less consequence in the execution of firing broadsides.

This import is that several corrections have been thought of to annul or diminish the deviation in the direction of the shots. These corrections, which were not made before the above-mentioned experiments, or which were allowed to be made at sight by the chief gunner, have considerably augmented the precision of firing, as the experiments have shown.

The results of these experiments have shown that the exactitude of the indications of the new krenometer may be held as entirely satisfactory, and, in consequence, this apparatus fully resolves the question of convergent firing—a very important question for firing broadsides, and which was begun to be worked, 30 years ago, in the different European fleets.

It may be remarked that at the same time that the experiments of convergent firing with the new krenometer were made, a system of the transmission of orders relative to the service of the artillery on board was then studied. This question, closely connected with convergent firing, is very important, because a system of signals which transmit orders rapidly and without confusion, put the firing of the artillery at the disposition of the commander, who can then direct with confidence.

Admitting, according to the results of the experiments, that the new krenometer gives exactly the position of the diametral plan, it is evident that, at a well-determined distance, the broadside will be always properly directed since the current is strict, and that the shot goes off at the moment in which the sight is exactly in the given direction of convergence, and that at the same moment the krenometer marks the indicated position of the diametral plan with the precision which is peculiar to it; that is to say, the desired inclination of the axes of the guns.

Nevertheless, when this instrument is used for convergent firing, the following must be remembered:—

Let us suppose that the vessel which is firing is at a precise distance from the object, and that the two ships are stationary, but with oscillations. Suppose, besides, that the centre of the object does not come upon the line of sight of the indicator. It is evident that during the

time of each oscillation, the current will be shut once, as has already been said, at the moment when the right perpendicular of the diametral plan will become horizontal. If it is admitted that in the interval of the oscillations there is time to load all the guns of the battery, a broadside will necessarily be sent at each oscillation.

Suppose now that the ship is stationary, but the object in motion, although always remaining at the same equal distance from that of the point of convergence. As the sight will always remain directed on the centre of the object, the conductors of the indicator will only be reunited when the sight following the movement of the object comes in the designated direction where the bolt of the conjunctor is placed. If at this moment the diametral plan oscillating passes by the position indicated in the krenometer, the conductors of this last will also be reunited, the current of the *inflammateur* will be shut and the broadside will go off; but if the reunion of the conductors of the indicator do not coincide with that of the conductors of the krenometer, the salvo will not take place, and it will be, in a measure, a miss-fire. It is evident that by reason of the precision of the shutting of these currents, there will often be false shots of this kind when firing while rolling, upon a movable object.

Let us examine if there are no means of parrying the want of coincidence, and how it can be done. Let us imagine upon the object a line AO (Fig. 9) at the same height above the water, at the perpendicular to the diametral plan of the ship which is firing; that is to say, as the line of sight. If the object were immovable, at each oscillation of rolling the line of sight would describe upon the surface of the object a straight vertical MN, and at each oscillation the shutting of the current would take place when this line should pass to the point O; that is to say, that at this moment would take place the coincidence of the reunion of the conductors of the indicator, and the reunion of the conductors of the krenometer. Let us suppose now that in one of these moments, when the line of sight passes to the point O, the object begins to move, with a uniform movement, from O towards A, whilst the ship which is firing remains immovable. In this case the line of sight will no longer describe upon the object the vertical MN; it would describe a straight MM inclined, if its movement of oscillation were uniform; but as it turns so much the less quickly as it removes further from the horizon, it describes the curve OCD above the horizon, and a similar curve, but turned the other way, when it is below the horizon. In other terms, the oscillating line of sight will describe an undulated curve upon the object. The height of each half undulation will depend solely on the amplitude of the oscillation, whilst its length will be equal to the way made by the object during the time of the oscillation; consequently this length will depend on the duration of the oscillation and speed of the object; the greater the speed of the object is, the greater will be the incline of the curve. It is clear that the points O, D, &c., of intersection of the undulated curve with the horizontal OBD, correspond to the reunion of the conductors on the krenometer; whilst the vertical MN corresponds to the reunion of the conductors on the indicator. We must remark that if we sup-

pose the undulated curve to be immovable, and in consequence the points E, O, D, we ought to imagine that the line MN is displaced with the object. It is not, therefore, difficult to see that the shutting of the current, that is to say, the coincidence, will only take place when the line MN passes over one of the points E, O, B, &c.

Having suggested the same rolling and the same speed of the object as previously, let us take the case in which the stem of the adversary A arrives upon the line of sight of the indicator, it coincides with the point A, that is to say, cuts the horizontal line AOB. It is evident that in this case the broadside will not go off, because the length Aa' of the half undulation will be greater than the half length of the object AO, and in consequence, when the vertical line MN comes upon the line of sight, this one will have risen to a. In order that the coincidence should happen in this case, it is necessary that the length of the half undulation ABO should be exactly equal to the half of the length of the object. From whence comes this condition? The movement of the object ought to be such that, during the length of an oscillation, it advances to the half of its length. We think it useful to remark that although we have supposed the ship which is firing fixed and the object movable, the reasoning applies to all cases, supposing the object animated with the relative speed of the two ships. In this way, when the course of the two ships draws them together, the relative speed will be the sum of the two speeds, and the undulation will be very long; for all other directions it will be shorter, and it will be minima when, the courses being parallel and in inverse sense, the relative speed will be equal to the difference of the speed. If, besides, in the case of parallel courses, the speed of the two adversaries is the same, there will be no undulations, and all will go on as if the two ships were immovable. After this it is not difficult to see how the failures of coincidence may be avoided. One of the means, for example, of allowing the going off of the broadside will be to be placed parallel with the adversary, and to take such a course as the centre of the object does not go out of the line of sight. In all other cases, if the broadside misses the first time that the centre of the object passes upon the line of sight, it remains to endeavour for some time to keep the centre of the object on the line of sight by means of the rudder, having in view the relative disposition of the ships. By this means a contrary movement to that of the ship is given to the line of sight, in consequence the relative speed and the length of the undulation are diminished. In all cases, if it be known how much the length of the undulation ought to be diminished, the certain firing of the guns may be relied upon, but as most of the time it is not known with what speed to move, the broadside may go off or not go off; that depends upon chance. However, it may be affirmed that it is much easier to obtain coincidences by means of the rudder, by going ahead of the adversary, in the case of parallel courses, than in the case of courses which meet, because, in this last instance, the relative speed of the object is always very considerable.

From what has been said the result is, that convergent firing, directed and perfected by means of the new apparatus, must considerably aug-

ment the precision of the firing of broadsides. But the question of knowing whether it is possible to send this broadside with precision depends—1st, on the state of the sea; 2ndly, on the relative disposition of the courses of the two adversaries; 3rdly, on the skill employed in the use of the rudder. We have already seen that if there is no impediment in the choice of the course, and if the ship which is firing is more swift by choosing a parallel course, the firing of the broadside may always be assured.

The introduction of the new apparatus constitutes, therefore, a notable perfection in convergent firing, a perfection which could not be expected from firing with the ordinary sights, even if they were corrected (which has never yet been done) of all the defects which might be prevented.

The precision of the new apparatus for convergent firing must make one believe that they could be still more perfected, by preventing the possibility of non-coincidences; considering besides that a remarkable amount of intelligence, imagination, and perseverance has been manifested in the study of these apparatuses, we have a right to hope that these new ameliorations will be introduced with the same success. However, should it happen that, notwithstanding every effort, the problem of avoiding non-coincidences, or miss firing, could not be resolved in the firing while rolling, by means of the electric krenometer, other means must be taken to ameliorate the salvos of convergent firing. We have already seen that in the high pointing of the guns by means of the krenometer, these guns are placed in a fixed position, with relation to the diametral plan, and the movement that the rolling gives them at each oscillation, brings their axes to the desired position, relatively to the horizon for a definite moment; consequently in this proceeding the axes of the guns possess a movement relatively to the horizon, which cannot be modified. If, on the contrary, always in rolling, a vertical angle is given to a gun by means of the sight, it is not necessary to wait until the rolling conducts the line of sight to the desired position, that is to say, to the centre of the object. The line of sight may be brought to this position independently of the rolling by acting in a proper way. It is to this proceeding that we must return if it should be impossible to annihilate the non-coincidences by using the krenometer, I mean to say that we must return to the use of the sight, but of a special sight intended for the broadsides of convergent firing, and different from those employed up to now.

Without entering into details as to the construction of this sight, which would divert us from the principal object of this article, we will try to explain the fundamental idea of the sight for broadsides of convergent firing.

To simplify, let us take a battery of two guns only placed in a turret. The first and most essential of the changes required by the use of the sight for convergent firing is to transport the apparatus for high pointing from the carriage to the frame. Besides which, this apparatus for pointing ought to be constructed in such a manner so as to be able to fire at any moment, as soon as the position is good,

without having to trouble as to whether the gunners have withdrawn their hands or not. The second change, which is no less necessary, is to take away the sight and the guide sight from above the gun and to place them separately outside of the piece. The construction of the sight is then about as follows: between the two guns of the turret a vertical upright is erected, AA (Fig. 10),[1] the superior extremity of which, penetrating above the top of the turret, forms a guide. This upright is furnished with a lateral trunnion B, the axis of which ought to coincide exactly with the axes of trunnions of the two guns. Upon this trunnion a long connecting rod, BC, is placed, the axis of which ought always to remain in the plane of the axes of the two guns. To obtain this result this connecting rod has been furnished with an apparatus for high pointing, nearly like that of the guns. The three apparatuses of pointing, that of the connecting rod and of each of the two guns, ought to be furnished with a common guide, the action of which causes the axes of the trunnions to turn round the plane which contains the axis of the connecting rod and that of the two guns. The other extremity C of the connecting rod BC is attached to the casting D, in which the rod of sight E slides. The superior extremity of this sight which rises above the top of the turret is furnished with the gauge of deviations, which moves in the space above the turret.

It may be seen by this description that the connecting rod of the sight, placed between the guns of the turret, and turning round the axes of the trunnions, constitutes an external straight line to each of the guns, but contained in the plane of their axes; this is why this sight does not differ in principle from the ordinary sight, but has over it, nevertheless, three advantages:—1st, it suppresses the interval of fire, which is so prejudicial to the precision of firing during the rolling; 2ndly, the distance between the sight and the guide may be sensibly greater, which augments the precision of the sight; 3rdly, the line of sight is in the open space, so that it may be brought into the centre of the object before it arrives in the direction of the shots.

With this sight the battery of a turret has no need of an indicator, and may do without the krenometer; this sight introduced in the current of the electric inflammator, may be used either for a broadside or a single shot.

To give the desired angle of inclination, the height of the sight corresponding to the distance of the object is taken, and the line of sight is directed on its centre. In disposing of the sector FAF′, in which the line of sight moves, it is possible, after having placed the turret so that the shots should go off in the direction chosen FA, to point the gun before the object comes upon FA; for that the sight must be brought into the position F′, then having brought the visual radius F′A upon the centre of the object, make the sight move without quitting the object. It is clear then when the sight comes into F the gun will be found pointed as well in a horizontal as a vertical sense. If, besides, the conductors are separated in two places upon

[1] Fig. 10 represents in perspective one only of the two guns, that on the left, and the exterior sight which in disposition would be hidden by the gun on the right.

the sight and upon the rule of the deviations, the shot will only go off when the sight is joined in the conjunctor in F, and that at the same time the conductors shall be reunited upon the sight. Nevertheless here the reunion of the conductors upon the sight is not automatical, but is executed at the will of the operator.

It may be understood that with this sight and the rolling it would not always be possible to bring the line of sight upon the centre of the object, but a good broadside may be fired in cases where that would have been impossible with the krenometer. For this the rule is, whatever may be the object, only to reunite the conductors upon the sight when the line of sight passes exactly by the centre of the object; the conductors on the rule may be reunited when the line of sight is at a little distance from the vertical of the centre of the object, provided this last is not too short.

We will add in conclusion that the sight we have just described, and which may be called the exterior sight, may be used equally in the pointing of the closed battery of a ship; for this the sight ought to be put in an open place, for example, on the upper deck, and all the guns ought to have a common guide for their pointing apparatus, which ought to be separated from the gun carriage and fixed upon the platform. The sight ought to be provided with a similar mechanism conducted by the common guide.

Until now we have only treated of the guns of a closed battery, whilst in our fleet there are many turret ironclads.

The firing of the guns from turrets pointed with the sight in the ordinary way is only possible in rare and exceptional cases, for a movable object cannot be followed by the narrow part of the turret. Thus the guns in turrets are furnished with a pendulum krenometer, which serves to give the angle of elevation when the object cannot be perceived with the sight. But as the indications of this apparatus are rough and inexact, we may remark that up to quite lately turret ships were very inferior compared with closed battery ironclads. However, the introduction of the electric krenometer into the turrets has raised the superiority which had been lost in this type of ship; a superiority for which end they have been built, and which allows them to fire at a distance where they offer a very little mark for the shots of a broadside ship, which always presents a much larger surface. Let us remark amongst other things that the establishment of the exterior sight above described in the turret is very simple, and only requires the removal of the apparatus of pointing; it must be admitted besides that it is less complicated than the electric krenometer.[1]

For a long time the idea has been conceived that in a ship with several turrets it would perhaps be more advantageous to make the firing from all the turrets converge, but this idea has never been seriously studied, and consequently never put into practice. Yet, on account of the necessity of striking the adversary with all the pro-

[1] We must remark in this place that experiments are actually being made upon the vessel "Pierre le Grand," with a sight, the superior extremity of which comes out above the turret, and which differs very little from that we have been describing.

jectiles at the same time, and of concentrating all the artillery to the disposition of one will, the convergence of the firing from the turrets is as important as that of the guns of a closed battery. Now that there is an electric inflammator tolerably perfect, and a telegraph for the communication of the orders, we have a right to hope for success in the convergence of firing from turrets.

In considering above firing with a sight and convergent firing, we have always supposed that the distance from the object was measured with exactitude, and besides, that at the moment of the broadside the centre of the object was at an equal distance to that of the point of convergence. However, up to now there is not in any fleet an apparatus capable of measuring the distance with sufficient precision. Besides, even should it be able to be measured exactly, it is measured a little before the shot is fired, and in most instances it would have been changed at the moment of firing in consequence of the sailing of the two adversaries.

In the pointing previously prepared, that is to say, in convergent firing, it would be advantageous to approach the enemy at a previously determined distance; but that would only be possible in a single combat, and by reason of having the superiority of sailing, and besides this would not be very easy, as it would always be necessary to have recourse to an instrument to measure the distance.

When the distance from the adversary cannot be known, the percentage of the shots diminishes, and the more so as this distance is greater. We must remark that in a naval battle one cannot hope to keep one's adversary within range, and the firing must be directed in such a manner that the whole broadside may reach. One may be satisfied with one per cent. less than a hundred when there is time to fire several broadsides, that is to say, to prolong the firing for a time.

As in consequence of the variation of the distance of ships under way, and the errors in estimating the distance, it is difficult to reckon that all the broadside will reach, at greater distances than three to three and a-half cables' lengths; therefore, to make the broadside perfectly efficacious when a good telemeter is not possessed, it will be better to give the guns an angle of invariable elevation. The magnitude of this angle is determined by the following considerations:—

For each gun with a given initial speed and a given height of the axes of the trunnions above the water-line, an angle of elevation may be found, M'*od* (Fig. 11), for which the summit C of the mean trajectory will be elevated above the level of the water by an amount equal to the height of the object *b*B. If the inevitable deviations are abstracted then the object will be reached by all the shots as long as it is a less distance than that AB', where that mean trajectory cuts the surface of the water. In consequence of the inevitable deviations on the contrary, a part of the shots comprised in the upper half to the mean trajectory will not reach the object in firing under the angle M'*od*. In order that this half of the shots should be distributed under the level *ob''bb'* of the upper part of the object, the gun must be given

an angle of elevation M*od*, a little less than M′*od*. In consequence of the inevitable deviations the distance from which the object shall always be reached will be AB″, that is to say, a little less than AB.

This angle of elevation, for which all the shots are sent under the upper level of the object, depends on the following reasons:—1stly, upon the calibre and the charge, that is to say, upon the curve of the trajectory; 2ndly, upon the elevation of the axes of the trunnions above the water-line; 3rdly, upon the height of the object. This angle must vary in the different batteries, but it will be less than 1° for all the guns on board.

If the ascertained deviations in the particular experiments of the Italian navy, and which are noted in Table II, are admitted for the guns of the fleet, then for the divers distances from the object and a constant angle of elevation, we may rely approximately upon 1 per cent. of shots indicated in the second column of Table IV for all the guns of a calibre of from 6 to 12 inches, and for the initial speed of 420 metres. If we look for the angle of elevation for which all the shots of our gun of 8 inches are distributed below the upper level of an object of the same height, that is to say, 5·5 metres, by taking the mean deviations given by our tables of firing, we find 1 per cent. of good shots, which is indicated in the third column of the same table. As the deviations which have served to determine the figures of the second column have been obtained in firing where the sight had not been corrected of its habitual defects, and as besides the Italian projectiles are not so precise as ours, it may be conceived that our guns fired with an improved sight will give 1 per cent. more good shots than that indicated in the second column. It is evident that this percentage will augment in proportion to the greatness of the improvements, without nevertheless reaching in any case the superior limit inscribed in the third column. To sum up, the percentage of good shots in the firing of our guns with a perfected sight and invariable angle of firing will be always comprised between the figures of the second and third column.

The result of this remark and of the examination of Table IV, is that firing in convergent salvos and under invariable angle of the guns of the Russian fleet at all distances less than three cable lengths the whole of the shots will strike the vertical of the object, and from three to three and a-half cable lengths, nearly the whole of the shots. Beyond this distance, on the contrary, hardly a single shot will strike the object.

The advantages of firing under an invariable angle of elevation are very evident.[1] With this mode of firing there is no need to know the distance from the adversary, it is sufficient that at the moment when the shot is fired, this distance is not greater than three cable lengths.

[1] The idea of firing under an invariable angle of inclination is not new, already the invariable angle was employed at the time of unrifled guns, and then the greatest distance corresponding to this angle was called point-blank.

TABLE IV.

Proportion of hits which fall upon a vertical line in firing under an invariable angle of elevation. Height of the object 5·5 *metres; elevation of the axes of the trunnions above the level of the water* 2 *metres for the second column and* 3 *metres for the third column.*

Distance in cables.	Percentage of hits. Elevation of trunnions 2 metres.	Percentage of hits. Elevation of trunnions 3 metres.	Observations.
½	100	100	*For 2nd Column.*
1	100	100	Calibre 22 cm.
1½	99	100	Angle of elevation, 0° 56′
2	98	100	Initial velocity, 435 m.
2½	97	100	
3	85	100	*For 3rd Column.*
3½	47	85	Calibre 20 cm.
4	10	14	Angle of elevation, 0° 54′
4½	0	0	Initial velocity, 421 m.

The fault of this process is not less visible; the limit of the distances in which all the shots may be good is too little. This fault is above all apparent when the chance of touching the object is considered, but if the destructive effect of the projectile is taken into account there are many cases in which this defect disappears, because the distance of firing under invariable angle is such that at greater distances the broadside could not produce the desired effect of perforation, even should the whole reach. To prove this fact it suffices to compare for each calibre the maximum distance at which 100 per cent. of good shots may be obtained with the distances to which a projectile of this calibre can pierce armour-plates of different thicknesses. In short, relying upon the results of simultaneous firing gone through in Germany, the distance cf perforation by a broadside of a given calibre will be greater than for a single gun of this calibre; perhaps also this distance will augment with the number of guns of the battery. However, we must not forget the dispersion of the lines of sight necessary for the good effect of the broadside, and which, augmenting with the distance, tends to weaken this effect. In this way it is always found, for the perforability by the broadside of a thickness of armour-plates, that the broadside will not pierce at greater distances than three cables' length.

There remain a few remarks to add to the preceding. All that has been said respecting the perforability by a broadside or a single shot has reference to the case in which the side is a plane surface and where the shots strike normally. This last instance is very rarely met with; and besides, all the armour-plated parts of vessels do not present plane surfaces. Now, it is known that if the shots are oblique

the distance of perforation of a same armour-plate is diminished; in the same way the perforability of a convex surface by a broadside cannot be compared to that of a plane surface. If we take for example a circular armour-plate covering a turret, or which comes to the same thing, a circular vessel, the action of each projectile taken separately cannot be the same, although the thickness of the armour-plate is everywhere alike. This may be well seen on Fig. 12, which represents the horizontal section of a turret. Of all the projectiles striking the turret the most advantageous will be that which strikes at the extremity of the diameter which projects in the direction of the shot; the others will be so much the less effectual as they will be farther from the former, because they will hit in a direction so much the farther from the normal. Admitting from the results of oblique firing against the armour-plates that the projectiles may yet damage the plates under an angle of 45° it will be necessary, to assure the effect of the salvo, to be at such a distance that the projectiles might still at this distance pierce the plates under the angle of 45°. We shall arrive by this means to the conclusion that with the guns and the armour-plates, such as they are now, if the aim is to perforate, the distance of the adversary ought not to be greater, whether firing a broadside or successive shots; and above all, we must not lose sight of the fact that the figures upon which we base to determine the distance at which an armour-plate shall be pierced are generally exaggerated. As there have been no experiments of firing at all distances we cannot determine the perforability at different distances. Usually, on account of the dimensions of the wall of experiment, the gun is fired at a uniform and short distance (shorter than one cable length) and the charge is reduced so as to give the projectile the same force that it would have at a determined distance when firing in a battle. If it is admitted that this great force has been well calculated, all the difference will consist,—1st. In that, at great distances, the trajectory does not meet with a vertical wall under the same angle as at little ones; and 2nd. In as, at little distances, the axis of the projectile coincides still with the tangent to the trajectory, whilst at greater distances there must be a certain angle with the direction of this tangent. Under the influence of these two causes a projectile at great distances hardly ever arrives at the normal, it hits in consequence in an oblique direction.

We must remark here that in point of view, particularly as to the destructive effect, it is necessary to employ the broadside every time that the shot of a single gun is powerless to pierce the wall of the enemy, in consequence the firing in broadside is so much the more advantageous as the calibre of the gun is much less. However, in order that the broadside should produce all its effect, two conditions ought to be realized: in the first place avoid the meeting of the projectiles before they reach the object; in the second place, the weaker the projectiles are, the nearer the point should be that they ought to strike. We have shown previously that to prevent the meeting of the projectiles it was necessary to give as much greater distance to the line of sight as the object was further off. These two conditions may

be reunited when the distance from the object is short, but as soon as it becomes a little longer it is impossible to realize all the effect of the broadside, because one of the two conditions can no longer be reconciled with the other.

When the question of perforation is examined, or more generally the destructive effect of the projectiles, the question of the choice of the projectile necessarily presents itself. If the armour-plate of the adversary is such that the guns one has may be able to pierce its wall at a given distance, the question is very simply solved if we can approach her just at that distance, but if these guns are not strong enough to pierce this wall either in single shots or broadsides, either she is covered with a too thick armour-plate, or that it is not possible to approach her at a proper distance for perforation, it is necessary to fire at parts less strongly protected. However, all ships, besides the guns which constitute their fundamental armament, have also guns of a less calibre, which may be very useful if judiciously employed. These guns, in truth, would be fired uselessly against the armour-plate, whilst their shells, directed against those parts not plated, may do a great deal of harm to the enemy. We find an example of this in the battle of Lissa. In that battle the artillery of the two adversaries was so weak that it could not, even at the shortest distances, have been able to pierce the wall of the ironclads present at the battle. Thus the Austrian ships only sent with their rifle guns of six inches, shells of ordinary cast iron, whilst the Italians, who had a quantity of this calibre,[1] only sent off shot powerless to pierce the armour-plate. The most important events of this battle, and which had a preponderating influence on its results, are the destruction of the ironclad "Re d'Italia," sunk by the ram of the Austrian ship "Ferdinand Max," and the explosion of another ironclad, the "Palestro." The explosion of this ship was produced, according to the explanation of M. De Luca, by an ordinary shell which penetrated into the interior through a part which was not armour-plated. Besides this, the author adds that the same accident nearly happened to three other ironclads, in which there was a commencement of fire, also brought about by the shells having struck a part not armour-plated. In truth, we must not forget that the Italian ironclads which took part in the battle were wooden ships; but in all cases the explosion of a shell in the interior of a ship will always be very dangerous. According to M. Luca, the "Re d'Italia" received the blow which sank her because her helm was broken.

Actually, on account of the different thicknesses of the plates which cover the breast of the ironclads, they are armed with guns of different calibres, it may be expected that the ironclads armed with guns of the greatest calibre encounter an adversary of which she may, at a considerable distance, perforate the wall, not only by her broadside, but

[1] According to M. de Luca, there was on the Italian fleet, besides the guns of this calibre, four guns of 9 inches (12 tons), and six Armstrong guns of 7 inches; but these guns, able to perforate the armour-plates of the Austrian vessel, had no piercing projectiles, and could only fire ordinary shells with thin coverings which broke against the armour-plates.

by a single shot. Attention has not yet been directed to this, because it has been specially occupied by the struggle of ships of equal armour-plates. It is, however, plain that such a projectile, even in traversing through and through the two walls of the adversary, has not produced all the effect it was intended. Even should it be a large projectile, the holes that it will pierce, and the approximate damage, will not be disastrous to the ship if they are above the water-line.

In this case all the destructive effect must be utilised, which must increase with the calibre of the projectile. Some trials, executed with the object of seeking the means of utilising the explosion of projectiles in the case in which their greater strength is equal or a little superior to that necessary to pierce the wall, have shown that it is better not to load these projectiles. Nevertheless, we are to apt to suppose that with a great excess of strength over that necessary to perforation it may happen that the projectile may explode after having gone through the first wall, and then the destructive effect would be much greater than if the shell had pierced the two walls. As we know by former experiments that a projectile of a relatively feeble resistance will perforate the plates when it is sent with a great excess of strength, it may be supposed that ordinary shells, or those a little thicker and heavier, may pierce plate of less thickness. All these questions can only be solved by experience; in the meantime the endeavour should be to perforate the armour-plates with a piercing projectile and attack the parts which are not armour-plated with ordinary shells of less calibre.

The convergence of firing is as necessary for precision as for the destructive effect of the shots.

In conclusion let us make the following remark :—All that has been already said shows that the convergent broadside ought to be used both for precision of firing as well as for destructive effect. Nevertheless, if it is possible to send a shot from a gun of such a calibre that the weight of the projectile should be equal to that sent off by all the guns of the battery, this shot will have a complete superiority over the broadside, as much on account of the precision as on the effect produced, and that superiority would be so much the greater as the object would be farther off; above all, if the necessary dispersion of the lines of sight to prevent the striking against each other of the projectiles before reaching the object is taken into account and also of the greater momentum of the large projectile.

The result of this is that the best means of assuring convergent firing consists in augmenting the calibre of the guns.

If the fortune of a naval battle could be decided at the first shot it would undoubtedly be advantageous to arm all the ships with a single gun, reuniting the weight of all the artillery intended for them. But, in the first place, the gun foundries have not yet produced a type the weight of which attains the amount of the weight of all the artillery of the largest ironclads; and moreover, the loading and the manœuvring between a shot and the following one require with big guns too much time in order that the ship armed with a single monster gun should be able to defend herself against two adversaries, which may

be necessary in a squadron battle. A ship is obliged therefore to be armed with several guns. The subject of this article does not permit us to enter into this question. We will limit ourselves then to remark that the arming of a ship with a single gun or a small number of guns is very advantageous for the facility which it gives for protecting the artillery; besides which, by the concentration of the artillery, room is gained on board and presents numberless advantages; but, as in the case where the adversaries have exchanged a first shot without touching each other, all will depend upon which can soonest send a second shot. It is clear that the smallest guns, which can be more rapidly loaded, will have the advantage. In order that guns of a heavy calibre may have the advantage under all circumstances over those of a small calibre, it is necessary to be able to load them with extreme promptitude.

Notes on Cavalry Tactics, Organization, &c. By a Cavalry Officer. London: C. Kegan Paul and Co., 1878. Pp. 282. Size 9″ × 6″ × 1¼″. Weight under 1¾lb. Price 12*s*.

WE owe many apologies to the author of this work for the delay in noticing it in the Journal. The fault is not, however, entirely our own. The object of the author is to "set forth the principles which should govern the action of cavalry in " war, as deduced from the campaigns of 1866 and 1870, after long and careful " study." "It is his endeavour to show first, what it is possible for cavalry to do, and " in what manner they may be employed to the greatest advantage, to demonstrate " in fact the proper tactical employment of the arm; secondly, to indicate the modifi- " cations in organization and equipment which appear to be necessary to enable it to " act in the manner previously laid down." Continuing to use as far as possible the author's own words, the tactics and formations of cavalry up to the present day are practically identical with those of a hundred years ago, and this, notwithstanding the entire revolution which has taken place in infantry and artillery, the time has therefore certainly come for seriously considering whether some modification cannot be introduced into the tactics of cavalry, by which they may be enabled to cope as successfully as of old with the other arms. If this be impossible, they will soon become obsolete on the field of battle. The principles for the action of cavalry in battle are: 1st, infantry and artillery, more particularly the former, should always be assailed in extended order; 2nd, the normal formation of cavalry must be in single rank; 3rd, the attack and preliminary advance must be made as rapidly as possible. Cavalry must be prepared under some circumstances to gallop long distances when advancing to the attack.

The second chapter deals with fighting on foot, and minor tactics generally; the third and last refer to reformed organization. "It is impossible to describe the " feeling of hopelessness and dismay which comes over one when entering upon " such a task as I have here attempted. Who can hope to move the dead weight of " professional opposition and apathy, which so successfully resists all efforts of this " nature?"

The value of the suggestions contained in the third chapter can, of course, only be rightly estimated by experts, but in the other two chapters will be found much food for reflection, not only for cavalry men, but for Officers of the other arms against which cavalry can be employed. Without pronouncing any opinion on the views propounded by the author, we can recommend it for perusal to all students of tactics.—L. H.

L'Armée Francaise en 1879. Par un Officier en retraite. Paris: Hetzel et Cie., 1879. Pp. 350. Size 7″ × 4½″. Price 2*s*. 6*d*.

General Trochu, in his latest work, bases his hopes of the future military power of France upon the formation of a true military spirit throughout the nation, in place of the fictitious warlike spirit which has hitherto been a national characteristic. This warlike spirit, fostered by successes for the most part over such foes as were to be met with in Algeria, had led the nation to consider its army invincible, so that prior to the war of 1870-71, solid preparation was entirely dispensed with. Since the re-organization of 1872, this has been changed, but General Trochu is still under the impression that the necessary spirit by which alone a nation can attain to real military power, is wanting. Borrowing from the German school, he would place all educational institutions upon a military basis, and thus instil throughout the whole country a military feeling, which should from earliest youth find a place in the education of every individual.

Passing from this broad principle, General Trochu condemns the recruiting law of 1872, which he attributes to an attempted compromise between the old long service and the new short service principles. By it, one portion of the annual contingent, approximately 90,000 men, is taken for a service of five years, whereas the remainder, some 60,000 men, are only required to serve for a maximum of twelve months. The latter period is too short, even when the maximum period is enforced, which was done last year for the first time. After a trial of six years General Trochu condemns the system, and urges, as he did in the National Assembly before the law of 1872 was voted, the adoption of an universal service of three years, the whole of the contingent being called up.

He regrets that the short service system should have led to the neglect of what he calls "military families." There are, he says, many families devoted by tradition and inclination to a soldier's career, but there are no facilities offered them for bringing up their children to follow it. By the creation of an extended system of military schools, he would hope to gain from these a valuable contingent towards recruiting the non-commissioned officers' ranks, which has of late been found so difficult a matter. The whole of this question is dealt with under the heads of the preparatory training to be provided for candidates, and the advantages to be offered to non-commissioned officers while serving and subsequently. Under the former head it is proposed to establish military schools in the several military districts, at the rate of one for every two army corps, to which admission would be granted at the age of from seven to eight years, and maintenance provided for in special cases in proportion to the military services of the parents. These children would be brought up to consider the career for which they are destined as the natural result and honourable reward of their efforts. Such of them as showed the necessary qualifications would, at the age of seventeen, be engaged for eight years' army service, of which two to be passed at non-commissioned officers' schools, to be created in the proportion of one to every three army corps. These schools would not be recruited from this source alone, but would also be open to all comers between seventeen and twenty years of age, under certain restrictions as to character and physical qualifications, and under the condition of entering into an eight years' engagement. Six months' service with a regiment, resulting in a satisfactory report, would in each case be the necessary preliminary to the course of school instruction.

As regards the advantages to be offered to non-commissioned officers while serving, General Trochu hopes that the law of the 22nd June, 1878, will meet the pecuniary portion of the question. It provides for bounties, partly in present and partly in deferred payment upon re-engagement, a graduated daily pay according to length of service, and a pension after fifteen years' service, of which five with the rank of non-commissioned officer. His further remarks on this subject bear upon the amelioration of the non-commissioned officer's position by alterations in the law regarding reduction, by a broader line of distinction being drawn between him and the private soldier, and by improvements in his quartering, messing, and equipment.

In discussing the new constitution of the General Staff, he says that a great mistake has been made in abandoning entirely the old system, with its many good

points, and in borrowing a new one from Germany, which has proved quite unsuited to the French army. The whole system was that of a closed corps, the principle of which General Trochu believes to be right, so far as the French army is concerned. But its application was defective, the corps being recruited from the pupils of St. Cyr, who were without experience or practical knowledge of any kind in military matters. In its place the National Assembly determined in favour of an open service in which staff and regimental employ should constantly alternate. In doing this, two mistakes were made. The system, as copied from the German, was found to lack a very material part, viz., the nucleus or permanent scientific staff, which in Berlin, under the guidance of Field Marshal von Moltke, controls and supervises the constitution and work of the staff generally. In France, this responsibility rests with the War Ministry, which is quite unable to supply its place. On this subject General Trochu writes: "*The creation and employment of specialists form one of the most imperative* "*laws of modern war, and, among all specialities, that of the General Staff is the* "*most important, because it embraces at once all the interests of direction as well as* "*of execution.*"

The second mistake has been in not selecting with more care the candidates for general employment, which is the more necessary in the French army because the average standard of education is not high.

As with the General Staff, so with the administrative services, General Trochu considers that a mistake has been made in changing the system previously in vogue, rather than in reforming its abuses. The new system rightly divides the services under three heads—the administration proper, the direction, and the control. The functionaries of this latter section are selected indifferently from civilians, combatant and departmental Officers, whose powers emanate directly from the Ministry. The Officers of the intendance exercising the "direction" are subjected to the "control" of these, who as a rule will have no experience of the working of their services, at the same time that they are subordinated to the Officer commanding the troops or district to which they are attached. Deprived of their responsibility, it is alleged that the energetic initiative for which the Officers of the intendance have always been noted, will cease also. But he foresees a still greater evil in the fear lest the responsibility of the administration should be found too heavy a burden for the Officer commanding. He condenses this question in the following sentences: "The military administration broke down from having wanted to command. The "executive will break down from wanting to administer."—L. H.

EXTRACTS FROM THE ACCOUNT OF A TRIAL MARCH UNDERTAKEN BY SOME OFFICERS OF THE ITALIAN CAVALRY IN NOVEMBER, 1878, AND WHICH APPEARED IN THE "ITALIA MILITAIRE" OF THE 30TH NOVEMBER, 1878.

Translated by Captain CECIL NORTON, 5th Lancers.

As we have already informed our readers, several Officers belonging to the Novara Cavalry Regiment executed a short time ago a trial march, in which they endeavoured to cover a distance of 500 kilometres[1] in five days, for the purpose of ascertaining the lasting power of their chargers without these having had any previous training.

The following was the road taken:—

[1] A kilometre = 1093·6 yards. 500 kilometres = about 310 miles English.

1. Milan, Bergamo, Rovato;
2. Rovato, Brescia, Peschiera, Verona;
3. Verona, Mantua, Carpi, Modena;
4. Modena, Reggio, Parma, Piacenza;
5. Piacenza, Stradella, Pavia, Milan.

Of the eight Officers who started, one stopped at Verona, and four others succeeded in accomplishing only one-half of the proposed distance, owing to circumstances connected with their horses; three performed the whole of the prescribed distance within 6 hours and 35 minutes of the allotted time.

The experiment, which was carried out under the worst conditions as regards season and weather, has furnished the most useful and satisfactory results, tending to elucidate the investigation proposed by these Officers, to whom the greatest praise is due for having undertaken the matter voluntarily, and having subjected themselves moreover to no small amount of fatigue, together with heavy personal expenses, not to speak of the risk as regards their horses.

All honour to these "experiments with reference to horses in a "military point of view," both preceded and accompanied by practice, that great master, more aptly described as indispensable rather than necessary in the cavalry, whose effective action must be always completely dependent upon, and subordinate to, the powers of its principal arm, viz., the horse.

Hence the interesting study of everything relating to this noble friend of the soldier cannot but prove useful, not only to all cultivators of the sciences relating to horses, but in the highest degree to cavalry Officers. We believe, moreover, that the perusal of the short diary concerning this march, which the Officers who performed it presented to their Colonel, and which by his courtesy has kindly been communicated to us, may prove acceptable to our numerous readers belonging to this branch of the Service.

The study of the execution of similar marches in as far as they relate to the horse, respecting the weight he carries, the manner in which he is ridden, the distribution of the rates of going, and the distances, will certainly be closely observed in this regiment and in others after this experimental feat; but in the meantime we are of opinion that the fact has been proved, that from well-bred, well-shaped horses one can exact extraordinary staying powers invaluable for very distant reconnaissances, and that our cavalry regiments possess zealous and intelligent Officers for the carrying out of such undertakings.

The following is the diary.

We think it right to mention that no sooner had it come to the knowledge of the Officer commanding the regiment, that some Officers proposed executing with their chargers a trial march, than he became anxious not only to grant them permission to do so and to facilitate the matter by every means in his power, but gave, moreover, to the undertaking that support which would cause it to furnish the most profitable results. To know what a horse not previously trained can do, and the care, feeding, and treatment in fact requisite, in order that he should stand fatigue, is in reality to know the training he

requires, and this practice furnishes us with much better than theoretical speculations of any kind, and the more so since on this subject there is considerable difference of opinion amongst the best authorities. There can be no doubt that such instruction, if useful to those who are fond of horses, ought to be a thousand times more so to those who look upon the horse as their chief arm.

The following were the Officers engaged in the undertaking:—

	Name of horse.	Race.	Sex.	Age.	Weight. Of rider.	Weight. Of horse trappings.
					lbs.	lbs.
Captain Bidoli Silvestro....	Ella	French	Mare	6	180	25
Lieut. Sartirana Galeazzo ..	Paesano	Italian	Gelding	9	152	28
„ Malatesta Paufilo....	Piccina	Hungarian	Mare	7	139	20
„ Guaragna Giuseppe..	Fürtz	„	Gelding	7	178	29
„ Solina Gaspare......	Paddy	English	Mare	9	158	24
„ Brunati Alessandro..	Gigi	Roman	Gelding	11	145	25
„ Bellofatto Carmine ..	Flick	Prussian	„	8	176	28
„ Angelini Fedeli	Wellington	Irish	„	7	158	24

Sunday, 3rd November, 1878.

Milan—Bergamo, 35 miles; Bergamo—Rovato, 23 miles.

Weather.—Fine, but very cold.

Leaving Milan at 6 A.M., Bergamo was reached by noon, with a previous brief halt at Vaprio. Started again at 2 P.M., arriving at Rovato at 6 P.M.; already dark.

State of the Roads.—Very bad, muddy, with deep ruts as far as Gorgonzola; tolerably good as far as Vaprio; good, but rather hard afterwards. The Vaprio tramway caused considerable and frequent annoyance to the horses.

Pace of Marching.—At the walk and at the trot. At a walk for the first hour and for an hour before reaching the halting-place for the night; then at a walk and at a trot alternately, with trots of 20 minutes' duration. The trot was short. The rate of marching was, on an average as pre-arranged, $5\frac{1}{2}$ miles an hour.

Feeding.—In the morning a small feed of hay and a few go-downs of chilled water with a little flour in it, $4\frac{1}{2}$lbs. of corn. The same at the halt, but only $3\frac{1}{3}$lbs. instead of $4\frac{1}{2}$lbs. of corn. At the end of the stage a moderate amount of hay, plenty of water, but given in two goes, $4\frac{1}{2}$lbs. of corn. The horses as soon as they got into the stable looked greedily for their forage, but soon became impatient to be watered.

Special Treatment.—Horses always well wisped, even though they came in dry; half an hour after coming in girths loosened. When the halting-place for the night was reached, the saddles were taken off

shortly afterwards. The horses had their legs, shoulders, and loins rubbed with spirits of camphor. In districts where the roads were unequally paved, and where the hills were steep, the riders dismounted and led their horses; for instance, going up the hill near Vaprio, after crossing the Adda.

The horses passed the night very well; after feeding they lay down at their usual time, and got up at the first touch.

Remarks.—The marching together of horses differing in race, breeding, and disposition, not trained to go in company, would naturally result, as it did in this instance, in their not being able to conform to each other's paces without prejudice to their powers, and even at the end of the first stage it was seen how the horses went back naturally, more or less, to their accustomed paces; and this tendency was almost in direct proportion to the distance traversed in all the successive stages.

Monday, 4th November.

Rovato—Peschiera, 35 miles; Peschiera—Verona, 20 miles.

Weather.—Fine; very cold during the early hours of the morning and towards evening. Fairly warm during the day.

Leaving Rovato at 6 A.M., reached Peschiera about 2 P.M.; short halt previously at Lonato, where the stabling was pretty good. A few horses were put up in the stables at the fort, which were cold, and the bedding was very scanty. Verona was reached at 6 P.M. The rate of marching was rather below the pre-arranged average.

Occurrences.—The horse Paesano, aged nine, bred near Mantua, of rather lymphatic temperament, having left Milan in not quite a fit state, was troubled a good deal by a cough, from which he was suffering when he started, and which had became aggravated perhaps by the cold stable at Peschiera. Upon approaching Verona he began to show signs of weakness. The other horses very fit. Mare Paddy's tongue very dry.

Feeding.—Same as before. A little salt was given them with their water.

Special Treatment.—Same as before, but more skilfully applied, owing to the valuable superintendence of the veterinary surgeon of the Alessandria Regiment. The stretch from Lonato to Decenzano, a short cut alongside of the railway, with steep hills and very stony, was gone over on foot by some of the riders.

The horses passed the night very well, with the exception of the horse Paesano, whose cough became worse and brought on in consequence a slight attack of fever, which prevented his continuing the march the following morning.

Remarks.—During the second stage the mare Paddy marched alone, in consequence of her fretting when in company with other horses. The delay at Brescia of about half an hour and the prolonged delay at Peschiera, and hence the considerable delay in reaching Verona, had doubtless a detrimental influence.

Tuesday, 5th November.

Verona—Mantua, 29 miles: Mantua—Modena, 40 miles.

Weather.—Fine up to 10 A.M., wind very cold and rain afterwards.

Leaving Verona at 5.15 A.M., reached Mantua at 10.15 A.M. The horses were put up in a good stable, and were well seen to. Started again at 11.30 A.M. The horses Wellington, Fürtz, and Flick had another halt at Gonzaga of about an hour and a half; the other horses had a two hours' halt. Stable cold.

The horse Wellington reached Modena at 9.30 P.M., the horses Fürtz and Flick at 10.15, the others at 2 A.M. on the 6th instant.

State of the Roads.—Good, very hard, slippery, on account of the rain, after passing Mantua. Hard and stony between Gonzaga and Carpi.

Rate of March.—The average of $5\frac{1}{2}$ miles was kept up only as far as Mantua. It was perhaps kept up afterwards by the horse Wellington, the horses Ella, Piccina, Paddy, and Gigi doing something under this, as they did the stretch from Mantua to Villa Savioli (beyond Borgoforte) at a walk, and other long stretches afterwards at the same pace.

The horse Paesano remained at Verona, the other horses in first-rate fettle, feeding well, free in all their movements, and in good spirits.

Feeding.—Same as before. At the halt at Mantua bran and crushed beans were added to the corn.

Special Treatment.—As before. By advice a partial embrocation was tried, and small doses of quinine wine given. The mare Ella, having bruised her foot, had it dressed with hot turpentine and tar. The fact of the stable being exceedingly cold, the water cold, the bedding scarce, the stalls close to the entrance door, and the horses having to stand without clothing had doubtless a pernicious effect. Wellington and Fürtz passed the night very well, Flick well, the other horses were a little beaten, Paddy, possibly on account of the chilliness of the stable and the cold water, had a slight attack of fever. All the horses, however, ate their allowance.

Remarks.—A more equal distribution of the distances would, it seems, have been prudent; this stage, in fact, was excessively trying, both on account of the distance gone over on worse roads than those met with during the preceding stages, and on account of night setting in early after this dark and rainy day. Consequently, with horses whose powers were exhausted, with increased distances to get over, and with the weather unfavourable, only three of the number were able to reach Modena on the evening of the same day. The others reached Carpi at 10 P.M., and the riders, not wishing their horses to get their feet knocked about by the rough pavement at this place, had them led on while they halted for dinner, and overtook the horses about an hour later.

Wednesday, 6th November.

Modena—Reggio, 18 miles; Reggio—Parma, 18 miles; Parma—Piacenza, 40 miles.

Weather.—Rainy in the morning; fine later on.

The horses Wellington, Fürtz, and Flick left at 8 A.M.; the horses Ella, Piccina, and Gigi at 2 P.M. The mare Paddy remained behind.

The first-mentioned horses reached Parma at 2 P.M., and started again at 5.30 P.M., reached Firenzuola at 11 P.M., and started again at 11.45 P.M. The others stopped at Reggio, which they reached at 6 P.M.

The horses Wellington, Fürtz, and Flick reached Piacenza at 2 A.M. on the 7th instant. Well stabled and seen to.

State of the Roads.—Good.

Rate of March.—The three horses that went on did 10 minutes' walking and 20 minutes' trotting for a third of the stage; 10 walking and 10 trotting for another third; 10, and sometimes 20, walking and 5 trotting for the remaining third. Before arrival and upon first starting they did an hour at a walk.

The horses Ella, Peccina, and Gigi did not proceed beyond Reggio; the first went lame on account of the bruise to the frog of her off fore; the second was knocked up by a cracked heel (near hind); the third with slight cracked heels on both fore. All of these had heat in all four legs.

Feeding.—Same as before.

Special Treatment.—As usual.

The horses passed the night well. The horse Flick had not finished his corn when starting from Piacenza; he fed, however, during the night.

Remarks.—Had the object of the undertaking been to get over the distance, and not to find out what amount of fatigue a horse can stand without detriment to his constitution, the horses that remained behind at Reggio could have accomplished the distance in the given time; but, upon the first symptoms of prostration, the continuance of the march was desisted from. It is satisfactory to be able to state that the horses were never touched either with whip or spur.

Thursday, 7th November.

Piacenza—Stradella, 22 miles; Stradella—Milan, 30 miles.

Weather.—Fine during the day; damp and cold in the morning and evening.

Starting at 8.30 A.M., from Piacenza, the horses were led for the first two-thirds of a mile. Reached Stradella at 2 P.M. As the horses were getting into that state in which delay in the stable, if of any length, is fatal, they were, as soon as they had finished their corn, led on for about 2 miles, when they were overtaken by their riders. From 7.30 P.M. till 8.30 P.M., they stopped at Certosa, and reached Milan at 11.25 P.M.

State of the Roads.—Good.

Rate of March.—The horses were not able to last long at a trot, which was not kept up for more than 10 minutes at a time; but, on the other hand, they took long and quick strides at the walk, and this was proved by their keeping pace with the horses belonging to the

other Officers of the regiment, who had come out to meet them. These they soon outstripped.

The rate of march was nearly 5 miles.

Feeding.—Same as before.

Special Treatment.—As usual.

The horses passed the night well. Visited in the morning by the veterinary surgeon, who made the following report, and which document we annex.

"Milan, 9th November, 1878.

"I inspected yesterday and several times this morning the horses "belonging to Messrs. Guaragna, Bellofatto, and Angelini, and am "satisfied that they are in a satisfactory state, in spite of the ex- "ceptional fatigue which they underwent during the long marches for "five days. Mr. Guaragna's horse is lively, and has a tendency to lie "down, but eats and drinks well. Mr. Bellofatto's horse is somewhat "prostrated, but eats and drinks well and regularly; his pulse is a "little slow, and his breathing a little quickened. This morning his "hind legs were a little puffed. Mr. Angelini's horse is almost in his "normal state, as regards all his functions, and lies down very little. "Yesterday morning he sweated a little all over, but there was no re- "occurrence of this.

"PEANO, V.S.

"To the Colonel Commanding the Regiment, Milan."

Remarks and Conclusions.

This march, like the one executed previously, brings us to the following conclusions:—

It is best to start at daybreak, and to endeavour to reach the halting place for the night by sunset; long halts on the road are bad; one or two short halts of a few minutes' duration suffice, and a third for as long as possible after two-thirds of the stage has been got over. These halts only suffice to feed the horse, hence do not delay this longer than is necessary after the regular functions of the respiratory organs have begun, and the blood is cool. To assist digestion it is well to lead the horses for two or three kilometres after they have fed. In consequence of this the rider should have a strong pair of boots. The jack boots, more particularly when the muscles of the leg had become distended by a long ride, rendered walking almost impossible, although only a few stretches of paved roads were done on foot. The number of hours which the horse rests must not be calculated from the time he enters till the time he leaves the stall, but the time during which the horse is feeding must be deducted, as well as the time during which he is being groomed, &c. The horse suffers more from fatigue during the hours of the night than during those of the day, since besides having to walk guardedly and with care, the habits which he has been accustomed to observe throughout the year are violated, and in fact those which he has been accustomed to observe all his life, viz., to rest the entire night; and consequently this march executed during the season of the year when the days are

short, cold, cloudy, and rainy, presents itself to us under the most unfavourable conditions.

This march as regards feeding, &c., gives rise to the following reflections: It appears, 13 lbs. of corn and $6\frac{1}{2}$ or $8\frac{1}{2}$ lbs. of hay, given in three feeds, is advisable. As regards drink, chilled water with a little flour and salt seems best. No horse suffered from gripes, and their digestive organs remained in the healthiest possible state. Horses carefully shod a few days before starting did not suffer about the feet. There was no case of exhaustion. English saddles with felt numnahs were used. There were no wounds and no spur marks.

As regards the rate of marching, in spite of repeated experiments, opinions not only do not coincide, but differ materially; 10 minutes at a walk and 10 at a trot alternately, which appears to answer best for ordinary marches, seems pernicious in long marches, since the passing from one pace to another is, although in a lesser degree, to be put against the effort which the animal makes to accelerate its pace with the load it carries, and the sum of all these efforts, in a long distance, reaches a high figure. Some think it a good rule to walk for 20 minutes and trot for 10; others, on the contrary, to walk for 10 and trot for 20 or even 30. Then there are horses which stand one better or worse than the other; for example, in the cases of the horses Fürtz, Wellington, and Flick, it was observed that whereas during the last stage, the two former, after doing a couple of thousand yards, gave signs of wishing to change the pace, the last mentioned could hold out longer and *vice versâ*.

In these marches the distances which can be gone over diminish in a certain degree according to the number of horses which go together, because to some it is as great an effort to conform to the pace of the leading horse as it is to keep up with him: the advantage which may be gained by emulation is nullified by the harm caused by plunging, shying, and excessive nervousness which is catching in animals, in which imitation is natural. Every stage over 50 miles for several successive days is an effort. Well bred, young, well shaped horses can do even more than this distance, others although specially gifted cannot do so with impunity, without loss of strength, that is to say, without losing that vigour which renders them fit for immediate use after the usual rest. Thus entire tactical units, squadrons, or regiments, even in training, could not consequently do this distance for five or six consecutive days without pernicious results, and naturally the greater the number of troops the less the distance that can be got over.

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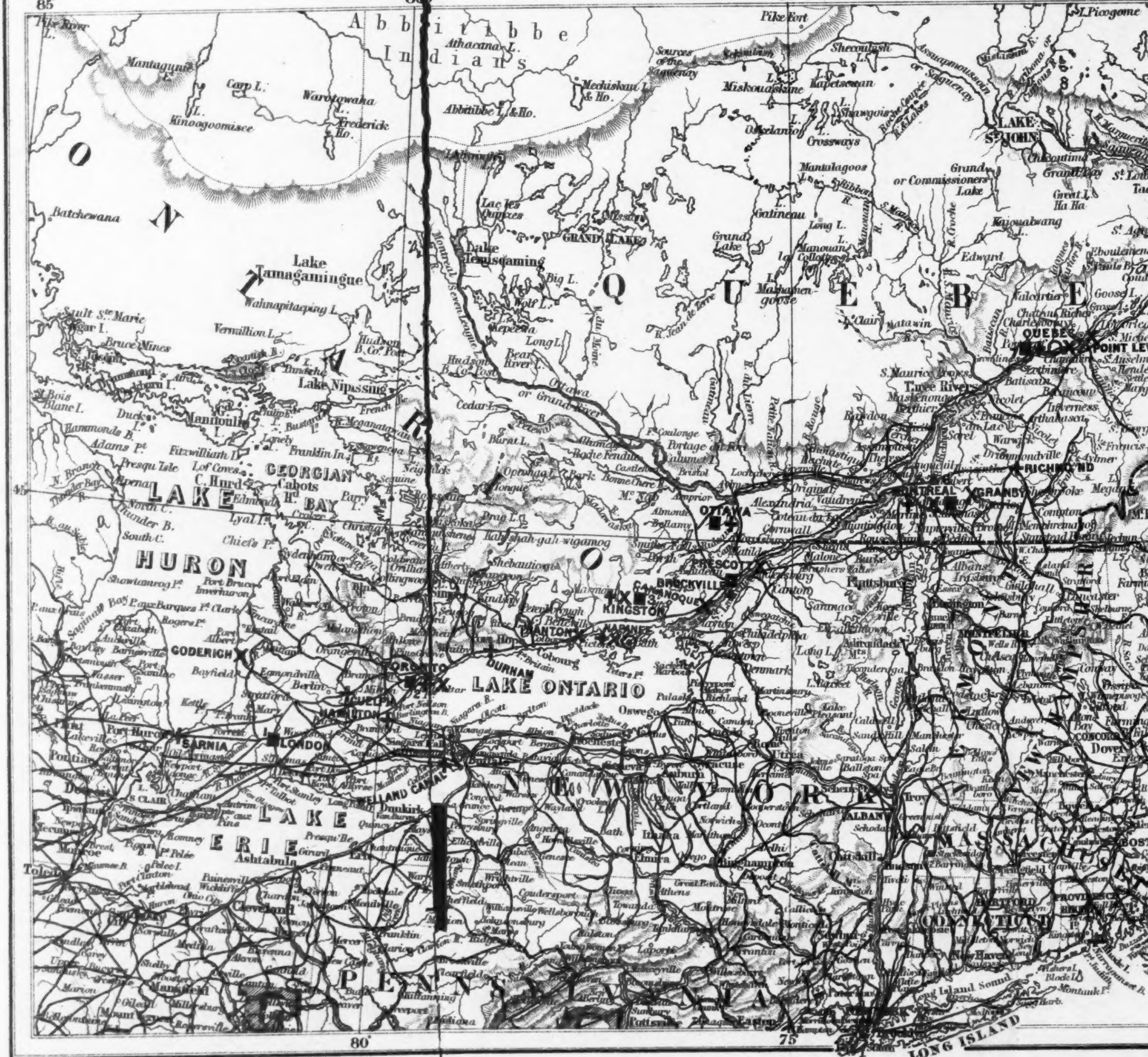

ASPECT OF CANADA

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